

Chemotaxonomic study of three *Artemisia* species growing in Sinai, Egypt

by

M. A. HELMY & M. H. GAZARA

(Botany Department, Faculty of Science, Suez Canal University)

ABSTRACT

A comparative chemotaxonomic study of three *Artemisia* species, *A. monosperma*, *A. judaica* and *A. herba alba* is presented. Eight forms of *A. monosperma*, growing in Wadi El-Arish (North Sinai) and the other two species growing in Wadi El-Sheikh and Wadi El-Talaa (Saint Catherine, South Sinai), respectively, were collected in the same growth season to eliminate the effect of ecological factors.

The chemical study comprised the preliminary phytochemical screening, investigation of total, watersoluble and acid-insoluble ash; carbohydrates; total nitrogen and amino acids; lipids; fatty acids and flavonoids. The results revealed that the eight forms of *A. monosperma* were greatly similar in their chemical composition. On the other hand, they differed qualitatively and quantitatively from the other two species, viz. *A. herba alba* and *A. judaica*. Therefore, the phytochemical results fully justified the systematic treatment.

INTRODUCTION

The genus *Artemisia* is of common use in folk medicine and in pharmaceutical preparations (BOULOS, 1983), and several compounds were isolated from its tissues. Most of these compounds are of medicinal interest. In this regard FAHMY et al. (1960) isolated four crystalline compounds from powdered leaves and flowering tops of *A. monosperma*. MAKUDOV et al. (1962) determined the essential oils, organic acids, tannins, sugars, ash and tars in blooms of *A. scoparia*.

Many authors identified and isolated a great number of flavone compounds from different *Artemisia* species: RODRIGUEZ et al. (1972) from seven *Artemisia* taxa; SEGAL et al. (1973) from *A. herba alba*; KHAFAGY et al. (1979) from *A. monosperma*; CHAZOULY et al. (1984) and BACHA (1984) from *A. judaica* and SALEH et al. (1985) from *A. monosperma* and *A. herba alba*. SAYED et al. (1979) studied the fatty acids of *A. absinthium*, while LAIVANT and PROSKURNIKOVA (1965) studied the amino acids of the proteins of *A. rhodantha*, qualitatively, quantitatively, and their seasonal fluctuations during the developmental phases. GARRONE et al. (1973) examined the levels of free amino acids in *A. vulgaris* and *A. verlotorum*. Also, KHANDMOV and CHAMSKOV (1976) studied qualitatively the amino acids in *A. diffusa*, *A. halophila* and *A. turanica*. HAMMOUDA et al. (1978) isolated an acetophenone derivative and coumarins from *A. monosperma*.

ALENSEEVA (1962) studied the metabolism of carbohydrates in *A. turanica* in various soils under desert conditions. MAKI (1968) isolated hemicellulose from leaves of *A. capillaris*. On the other hand, GARRONE et al. (1973) examined the levels of soluble carbohydrates in *A. vulgaris* and *A. verlotorum*.

A critical taxonomical revision was realized by GAZARA (1987) for *Artemisia* species growing in Sinai and known earlier by TACKHOLM (1974). In this revision, it was possible to distinguish between different *Artemisia* species according to vegetative, head as well as floral characters. The following key was made by GAZARA (1987).

- 1.a Heads homogenous, oblong, tapering at base *A. herba alba*
- 1.b Heads heterogenous, hemispherical to oblong-ovate, not tapering at base 2
- 2.a Involucral bracts hairy, bisexual flowers fertile, 15-29 per head *A. judaica*
- 2.b Involucral bracts glabrous, bisexual flowers sterile, 3-9 per head 3
- 3. Heads ovate, 4 mm long, female flowers 2-6 per head *A. monosperma*

In the present study a chemotaxonomical investigation was carried out to compare the three *Artemisia* species, namely *A. monosperma*, *A. judaica* and *A. herba alba*, and between the eight different forms of the first species.

MATERIAL AND METHODS

The material used in the present investigation was obtained from *A. judaica*, *A. herba alba* and *A. monosperma* growing naturally in Sinai. The two first species were collected from South Sinai (Saint Catherine area). *A. judaica* was collected from Wadi El-Sheikh and *A. herba alba* from Wadi El-Talea. The eighth different forms of *A. monosperma* (A1 - A8) were collected from Wadi El Arish, North Sinai. The plant samples of the three species were collected at the same growth season. The shoots were manually cleaned, dried in an oven at 50 C and reduced to fine powder.

The preliminary phytochemical screening was carried out on the powdered dried shoots of the three different species of *Artemisia*. This included testing for volatile oils (BALBAA et al. 1981), tannins (A.O.A.C., 1975), unsaturated sterols (BRIESKORN et al. 1961), flavonoids (WALL et al. 1954 and BALBAA et al. 1981), glycosides and/or carbohydrates (VOGEL 1978), and saponins (WALL et al. 1954 and ABD EL MAKSOUD 1983).

The total ash, water-soluble ash as well as acid-insoluble ash were determined according to A.O.A.C. (1975) methodology, using two grams of the powdered air-dried shoots of the eight different of *A. monosperma* (A1 - A8), as well as *A. judaica* and *A. herba alba*.

The total carbohydrates were determined according to the A.O.A.C. (1975) method, and the sugar content was expressed as gram dextrose generally glucose per 100 gram dry weight. The qualitative investigation of the free and combined sugars was realized according to A.O.A.A. (1975) methods of analysis.

The total nitrogen content was determined by the micro-kjeldhal method (ALLEN et al. 1974). Amino acids and lipid contents were investigated according to ALLEN et al. (1974). Flavonoids were investigated according to A.O.A.C. (1975) and Bacha (1984) methodology. Finally, fatty acids were studied using gas - liquid chromatography according to A.O.A.C. (1975) methodology. The analysis was done by GC chromatograph using the following conditions:

- Column	10 % PEGA
- Column temp.	70 C (initial temp.)
- Rate	8 C/min.
- Final temp.	190 C
- Final time	20 min.
- Chart speed	2 min./cm.
- N2	30 ml/min.
- H2	33 ml/min.
- Air	330 ml/min.

Table (1): Preliminary phytochemical screening of shoots of three species of *Artemisia*

Test	Species		
	<u><i>A. monosperma</i></u> (A1-A8)	<u><i>A. judaica</i></u>	<u><i>A. herba alba</i></u>
Volatil oils	+ ve	+ ve	+ ve
Tannins	- ve	- ve	- ve
Unsaturated sterols	+ ve	+ ve	+ ve
Alkaloids	- ve	- ve	- ve
Flavonoids	+ ve	+ ve	+ ve
Glycosides and/or	+ ve	+ ve	+ ve
Carbohydrates	+ ve	+ ve	+ ve
Saponins	+ ve	+ ve	+ ve

RESULTS AND DISCUSSION

Investigation of plant constituents:

The principal chemical constituents were studied in order to compare between the eight forms of *A. monosperma* on one hand and between the three *Artemisia* species on the other hand. It can be concluded from Table (1) that all the three species of *Artemisia* contained volatile oils, carbohydrates and/or glycosides, flavonoids, sterols and saponins. Negative results were obtained for tannins and alkaloids in all of them.

Results presented in Table (2), revealed that the percentages of total ash content were approximately similar in different forms of *A. monosperma* ranging between 7.5 and 8.0 g.%. On the other hand the percentages were 7.5. and 8.5 g.% in *A. judaica* and *A. herba alba* respectively. It is clear also that water-soluble ash content in *A. monosperma* were approximately similar in different forms ranging between 3.5 and 4.0 g.%. Obviously, the records were 4.0 and 2.5 g.% in *A. judaica* and *A. herba alba* respectively. Results also clarified that the acid-insoluble content of different forms of *A. monosperma* ranged between 0.5 and 1.0 g.%. *A. judaica* and *A. herba alba* on the other hand had higher values of 2.8 and 2.3 g.% respectively (Table 2).

It is clear that the eight forms of *A. monosperma* had similar contents of total ash as well as water-soluble and acid-insoluble ash content. These contents differed from those of the other two *Artemisia* species. Although the total ash and water-soluble ash of *A. judaica* were similar to those of *A. monosperma* the acid-insoluble ash was much higher. The contents of the three types of ash in *A. herba alba* differed from those of the other two species.

Results presented in Table (2) clearly show that the total carbohydrate contents of the studied *Artemisia* species belonging to *A. monosperma* (A1 - A8) attained values that ranged between 0.83 and 0.879/100 g. dry matter. On the other hand, data collected for *A. judaica* and *A. herba alba* indicated higher values (2.42 & 2.60) g.% respectively).

The qualitative study of sugars presents in the three studied species using paper chromatography (Table 3) revealed that *A. monosperma* with all different forms contained galactose. The other two species, namely *A. judaica* and *A. herba alba* contained mannose. All the forms of *A. monosperma* differed from the other two *Artemisia* species.

Table (2) A: Quantitative Analysis of the three *Artemisia* species

Species Characters	A. monosperma								A. judaica	A. herba alba
	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈		
Total Ash (g.%)	7.5	7.5	7.5	8.0	7.5	8.0	8.0	7.5	7.5	5.5
Water Soluble Ash (g.%)	4.0	4.0	3.5	4.0	4.0	4.0	4.0	4.0	4.0	2.5
Acid - Insoluble Ash (g.%)	0.5	1.0	1.0	0.5	0.5	1.0	1.0	0.5	2.8	2.3
Total Carbohydrates as g.% glucose	0.87	0.83	0.83	0.83	0.87	0.87	0.87	0.83	2.42	2.60
Total Nitrogen content g./100g. plant material	0.286	0.276	0.286	0.286	0.286	0.276	0.276	0.276	0.332	0.350
Percentage of alcoholic extract (crude flavones)	3.28	3.31	3.37	3.24	3.28	3.28	3.37	3.28	0.50	0.40
Total Lipid content g.%	15.4	15.4	14.2	15.4	14.2	15.4	14.2	14.2	10.2	8.2

Results in Table (2) also show that the amounts of the total nitrogen content attained their maximum values in *A. judaica* (0.332 g%) and *A. herba alba* (0.350 g%) that decreased remarkably in the eight forms of *A. monosperma* (0.276-0.286 g%).

The results of total lipid content (Table 2) estimated quantitatively in the different forms of *A. monosperma* (A1 - A8) indicated values that ranged between 14.2 to 19.4 g%. On the other hand, both *A. judaica* and *A. herba alba* indicated lower values of 10.2 and 8.2 g% respectively.

The percentages of the alcoholic extract, containing total flavones, were also compared (Table 2). It is evident that the crude total flavonoid content of the eight forms of *A. monosperma* were similar, ranging from 3.24 to 3.31 g%; however *A. judaica* contained only 0.5 g%; nevertheless *A. herba alba* contained the least amount of flavonoids (0.14 g%).

The results of the qualitative study of amino acids in the three studied species using paper chromatography (Table 3) revealed that *A. monosperma* with all its different forms contained lysine, asparagin, aspartic acid, glutamic acid, alanine, tyrosine, methionine and leucine. On the other hand, *A. judaica* contained lysine, aspartic acid, glutamic acid, alanine, tyrosine, valine, and leucine; while *A. herba alba* contained cystine, lysine, asparagin, serine, alanine, valine and isoleucine.

Considering the qualitative investigation of flavonoids (Table 3) *A. monosperma* contained quercetin 3-glucoside, quercetin 3-rutinoside, quercetin 5-glucoside, isorhamnetin 5-glucoside, patuletin 3-rutinoside, acacetin 7-glucoside, acacetin 7-rutinoside, vicenin -2, lucenin and methylated aglycones as reported by SALEH et al. (1985). Differently, *A. judaica* contained chrysoeriol 7-rutinoside, leutulin, cirsartakogenin (BACHA 1984). Finally, *A. herba alba* contained quercetin 3-glucoside, quercetin 3-rutinoside, patuletin 3-glucoside, patuletin 3-rutinoside, isovitexin, vicenin -2 schaftoside, isoschaftoside and methylated aglycones (SALEH et al. 1985). These results clarify the presence of different flavones in the three *Artemisia* species. The results also show that the eight forms of *A. monosperma* contain the same flavones, and differ from the other two species.

The results presented in Table (4) reveal the presence of the following fatty acids in the eight forms of *A. monosperma*: octanoic, capric, lauric, tridecanoic, myristic, pentadecanoic, palmitic, stearic, oleic, linoleic, linolenic and arachidic acids. It is also clear that *A. judaica* contained a group of fatty acids similar to that of *A. monosperma*, with the difference that undecanoic acid is present, while octanoic and arachidic acids are absent. On the

Table (3): Qualitative analysis of Carbohydrates, amino-acids, flavonoids and fatty acids of the three *Artemisia* species

Species Characters	<i>A. monosperma</i>								<i>A. judaica</i>	<i>A. herba-alba</i>
	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈		
Carbohydrates										
Galactose	+	+	+	+	+	+	+	+	-	-
Mannose	-	-	-	-	-	-	-	-	+	+
Amino acids										
Cystine	-	-	-	-	-	-	-	-	+	+
Lysine	+	+	+	+	+	+	+	+	+	+
Asparagine	+	+	+	+	+	+	+	+	-	+
Aspartic acid	+	+	+	+	+	+	+	+	+	-
Glutamic acid	+	+	+	+	+	+	+	+	+	-
Serine	-	-	-	-	-	-	-	-	-	+
Alanine	+	+	+	+	+	+	+	+	+	+
Tyrosine	+	+	+	+	+	+	+	+	+	-
Methionine	+	+	+	+	+	+	+	+	-	-
Valine	-	-	-	-	-	-	-	-	+	+
Isoleucine	+	+	+	+	+	+	+	+	+	-
Threonine	-	-	-	-	-	-	-	-	-	+
*Flavonoids										
Quercetin 3-glucoside	+	+	+	+	+	+	+	+	-	+
Quercetin 3-rutinoside	+	+	+	+	+	+	+	+	-	+
Quercetin 5-glucoside	+	+	+	+	+	+	+	+	-	+
Isochaereticin 5-glucoside	+	+	+	+	+	+	+	+	-	-
Petalutin 3-glucoside	+	+	+	+	+	+	+	+	-	+
Petalutin 3-rutinoside	+	+	+	+	+	+	+	+	-	+
Acacetin 7-glucoside	-	-	-	-	-	-	-	-	-	+
Acacetin 7-rutinoside	+	+	+	+	+	+	+	+	-	-
Isovitexin	+	+	+	+	+	+	+	+	-	-
Vicinin - 2	+	+	+	+	+	+	+	+	-	+
Schaftoside	-	-	-	-	-	-	-	-	-	+
Isochaetoside	-	-	-	-	-	-	-	-	-	+
Locenin - 2	+	+	+	+	+	+	+	+	-	-
Methylglyoxal	+	+	+	+	+	+	+	+	-	+
Chrysoeriol 7-rutinoside	-	-	-	-	-	-	-	-	+	-
Leutalin	-	-	-	-	-	-	-	-	+	-
Cirsitolonin	-	-	-	-	-	-	-	-	+	-
Apigenin	-	-	-	-	-	-	-	-	+	-

* Identified by BACHA (1984) & SALEH et al. (1985).

Table (3) Qualitative analysis (Cont.)

Species Characters	<i>A. monosperma</i>								<i>A. judaica</i>	<i>A. herba-alba</i>
	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈		
Fatty acid esters										
Octanoic										
Octanoic	+	+	+	+	+	+	+	+	+	-
Capric	+	+	+	+	+	+	+	+	+	+
Undecanoic	-	-	-	-	-	-	-	-	-	-
Lauric	+	+	+	+	+	+	+	+	+	+
Tridecanoic	+	+	+	+	+	+	+	+	+	+
Myristic	+	+	+	+	+	+	+	+	+	+
Pentadecanoic	+	+	+	+	+	+	+	+	+	+
Palmitic	+	+	+	+	+	+	+	+	+	+
Stearic	+	+	+	+	+	+	+	+	+	+
Oleic	+	+	+	+	+	+	+	+	+	+
Linoleic	+	+	+	+	+	+	+	+	+	+
Linolemic	+	+	+	+	+	+	+	+	-	+
Arachidic	+	+	+	+	+	+	+	+	-	-

Table (4): Percentages of fatty acid esters of the three studied *Artemisia* species

Species Fatty acid	<i>A. monosperma</i>								<i>A. judaica</i>	<i>A. herba-alba</i>
	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	A ₈		
Octanoic	5.84	0.82	9.09	22.57	5.75	6.85	4.59	0.82		25.87
Capric	26.16	9.33	12.12	4.27	16.09	21.27	25.22	9.33	24.31	7.71
Undecanoic	-	-	-	-	-	-	-	-	2.78	-
Lauric	1.11	0.27	0.22	1.65	0.81	2.95	0.33	0.27	8.10	8.81
Tridecanoic	0.47	1.51	2.98	5.37	2.01	5.32	3.49	1.51	2.31	12.11
Myristic	3.96	0.96	1.5	2.20	2.76	11.82	2.18	0.96	3.86	5.50
Pentadecanoic	4.42	16.58	9.20	34.17	9.58	14.65	4.80	16.58	27.39	4.41
Palmitic	50.49	15.79	17.86	11.3	21.86	24.82	16.38	15.79	1.93	2.75
Stearic	0.32	1.57	2.71	1.65	1.53	0.83	0.76	1.57	3.70	1.47
Oleic	0.26	9.02	8.44	3.05	7.66	0.59	15.07	9.02	4.63	17.61
Linoleic	3.47	36.84	18.99	8.79	25.21	0.89	16.81	36.84	7.41	13.76
Linolenic	2.24	5.26	12.99	3.67	3.58	2.92	8.73	5.26	13.58	-
Arachidic	1.26	2.05	3.90	1.22	3.16	7.09	1.64	2.05	-	-

Other hand *A. herba alba* contained octanoic, capric, lauric, tridecanoic, stearic, oleic, linoleic, acids, and was free of undecanoic, lineolenic and arachidic acids. These results show that the percentage of some fatty acids varies not only in the three *Artemisia* species, but also in the forms of *A. monosperma* (Table 4). It must be noted that the qualitative estimation of fatty acids esters by Gas Liquid Chromatography is strict since it depends on comparing the fatty acids by authentic samples. On the other hand, the quantitative estimation of some fatty acids by the same method may differ since the peak shape differs in operating conditions and injection technique.

It can be concluded that the eight forms of *A. monosperma* contain the same fatty acids, which differ from those of the other two species viz. *A. judaica* and *A. herba alba*.

From these results, it is clear that the eight forms of *A. monosperma* are greatly similar in their chemical composition. They differ qualitatively and quantitatively from the other two species, viz. *A. judaica* and *A. herba alba*. In this regard, the phytochemical study fully justifies the systematic treatment.

REFERENCES

- ABD EL MAKSOUD, K.A., 1983: Ecological and phytochemical studies on one of the desert plants. M.Sc. Thesis, Fac. Sci., Al-Azhar Univ., Cairo, Egypt.
- ALEKSEVA, L.N., 1962: Metabolism of carbohydrates. *Uzbeksk. Biol. Zh.*, No 6, 13-19. (c.f. chem. abstr., 1963, 58: 10505).
- ALLEN, S.E., GRIM SHAW, H.M., PARKINSON, J.A. and QUARMBY, C., 1974: Chemical analysis of ecological materials, 1 st. Edition, P. 265, Blackwell Scientific Publications, London.
- Association of Official Agriculture Chemists (A.O.A.C.) 1975: Official Methods of Analysis, 12 th Ed., Washington DC., USA.
- BACHA, R.M., 1984: Chemical constituents of *A. judaica*. Ph.D. Thesis, Chem. Dep., Fac. of Science, Suez Canal University.
- BALBAA, S.I., HILAL, S.M. and ZAKI, A.Y.; 1981: Medicinal Plant Constituents. General Organization for Universities and School Books, Cairo, Egypt. P. 23-25, 279-280, 312-314, 366-367, 379-397.
- BOULOS, L., 1983: Medicinal Plants of North Africa. *Algonaac*. Michigan: Reference Publications Inc. P. 55, 57.
- BRIESKORN, G.H., KHUGER, K. and POLONIUS, W., 1961: Terpenes and sterols in leaves of *Salvia triloba* and *Pyrus malus*. *Pharm.*; 29: 389-391.

- CHANDRASEKHARAN, I., KHAN, H.A. and GHANIM, A., 1981: Flavonoids of *A. scoparia*. *Planta Medica*, 43 (3): 310-311.
- FAHMY, I.R., AHMED, Z.F. and ABDEL MONEIM, F., 1960: A phytochemical investigation of *A. monosperma*. *J. Pharm.*, United Arab Republic, I, No. 1: 83-95.
- GARRONE, A., LOMBARD, V., POLDINI, L., ROSSETTI, V., SCIONA, T. and TOURN, M.L., 1973: Botanical and chemotaxonomic study of *Artemisia vulgaris* and *A. verlotorum*. *Bot. Ital.*, 15: 22-23.
- GAZARA, M.H., 1987: Taxonomic revision and phytochemical study on *Artemisia* species growing in Sinai. M.Sc. Thesis, Bot. Dept., Fac. Sci. Suez Canal University, Egypt.
- GHAZOULY, D., MAGED, G. and OMAR, A.A., 1984: Flavonoid constituents of *A. campestris*. *Fitoterapia*: 55 (2): 115-116.
- HAHMOUDA, F.M., RIZK, A.M., ISMAIL, S.I. and HASSAN, M.M., 1978: Isolation of an acetophenone derivative and coumarins from *Artemisia monosperma* Del. *Fitoterapia*, vol. XLIX - N 2: 53-55.
- KHAFAGY, S.M., EL-GHAZOOLY, M.G. and METWELLY, A.M., 1979: Isolation and characterization of two methoxylated flavones from *A. monosperma*. *Pharmazie*: 34 (11): 748-749.
- KHAMAMOV, I.KH. and CHAMERKOV, S.-KH., 1976: Amino acid composition of some fodder species of wormwood (*Artemisia*). *Inst. Samarkand, USSR. Akad. Nauk. Uzb.*; I: 40-42. (c.f. chem. Abstr. 1977, 80: 118290).
- LAIVANT, A.S. and PROSKURNIKOVA, T.A., 1965: Dynamics of amino acids in the proteins of *A. rhodantha*. *Obmen Veshchestv U. Zhivotn. Bost.*, Akad. Nauk kirg. SSR. 164: 73-88 (c.f. chem. abstr. 1965, 63: 12002 g.).
- MAKI, M., 1968: Isolation of hemicellulose from leaves of *A. capillaris*. *Sato, Yukio, Eiyo to Shokuryo*; 20 (5): 378-381. (c.f. chem. abstr. 1968: 69: 18999m).
- MAKSUDOV, N.KH., POGORELKO, I. P. and YULDASHEV, P. KH., 1962: A chemical investigation of *A. scoparia*. *Usbeksk. Khim. Zh.* 6, (5): 84-86. (c.f. chem. abstr., 1963, 58: 10514h.).
- RODRIGUEZ, E., CARMEN, M.J., VENDER, V.G., MEREYNIDES, J.H., HARBY, T.J., IRWIN, M.A. and GEISSMAN, T.A., 1972: Methoxylated flavonoids from *Artemisia* species. *Phytochemistry* 11 (12): 310-314.
- SALEH, N.A.M., EL NEGUMY, S.I., ABD ALLA, M.F., ABOU ZAID, M.M., DELLAMONICA, G. and CHOPIN, J. 1985: Flavonoid glycosides of *A. monosperma* and *A. herba alba*. *Phytochemistry* 24 (1): 201-203.
- SAYED, DARWISH, M., EL SHAMY, A.M., SOLIMAN, F.M. and EL SHABRAWY, 1979: Study of fatty acids of *A. absinthium*. *Bull. Fac. Pharm.* 16 (1). 85-98.

- SEGAL, R., COHEN, D., SOKOLOFF, S. and ZAITSCHEK, D.V.,
1973: New flavone from *A. herba alba*. *Lloydia*
36 (1), 103-105. (c.f. chem. abstr. 1973: 79,
29521n).
- TACKHOLM, V., 1974: Students Flora of Egypt. Cairo Univ.
2 nd Edition. Cooperative Printing Co. Beirut.
p. 579-581.
- VOGEL, A.I.: A Textbook of Practical Organic Chemistry.
4 th Ed. p. 1078.
- WALL, H. E., KREIDER, M. M., KREMSON, C. F., EDDY, G. R.,
WILLIAMM, J. J., COVELL, D. S. and GENTRY, H. S.:
1954: Steroidal saponins. VII. Survey of plants
for steroidal saponins and other constituents. *Jour.*
Pharm. Soc. 43: 1-3.

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-
Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Mitteilungen der
Botanischen Staatssammlung München](#)

Jahr/Year: 1989

Band/Volume: [28](#)

Autor(en)/Author(s): Helmy M. A., Gazara M. H.

Artikel/Article: [Chemotaxonomic study of three
Artemisia species growing in Sinai, Egypt 575-
587](#)