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HMI and ANA conceived and designed the study. HMI and AAM performed the experiments. HMI and FAA analyzed data, wrote and revised the paper.

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## *Bidens aurea* (Asteraceae), a new record to the Flora of Yemen

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#### Abstract:

A field survey was conducted on the genus *Bidens* L. in Sana'a city during the period April to September 2019. A total of four *Bidens* taxa were collected from different locations in Sana'a city. Three of them were matched with the three recorded *Bidens* species in Yemen flora (*B. bipinnata*, *B. biternata*, and *B. pilosa*). However, the fourth collected *Bidens* taxon was considered to be a new record to the flora of Yemen, namely *Bidens aurea* (Aiton) Sherff. A morphological diagnostic was carried to illustrate the morphological characters of the new record *Bidens* taxon. Based on 42 morphological leaf characters (26 qualitative and 16 quantitative), a comparison study and static analysis (UPGMA) were made to demonstrate the taxonomical relationship between the new recorded *Bidens* taxon and the closely related *Bidens* spp. cited in the flora of Yemen. The new recorded *Bidens* taxon showed a similarity to the closely related *Bidens* taxa mentioned in the flora of Yemen in 9 qualitative leaf morphological characters. However, twenty leaf morphological (11 qualitative and 9 quantitative) characters showed an important taxonomic value in differentiating between *B. aurea* and the other three *Bidens* species recorded in the flora of Yemen.

## INTRODUCTION

The genus *Bidens* L. is one of the largest genera in the family Asteraceae, subfamily Asteroideae and tribe Heliantheae Cassini (Takhtajan, 2009; Chen and Hind, 2011).

Based on Sherff (1932; 1937); Sell and Murell, (2005) and Chen and Hind (2011) the genus *Bidens* consists of 208 to 250 species classified into 14 sections (*Campylotheca*, *Degeneria*, *Neurophyllum*, *Clomtonial*, *Greenmania*, *Selvorngaea*, *Fulsotsia*, *Heterodonta*, *Meduseae*, *Platycarpaea*, *Psilocarpaea*, *Steppia*, *Lesperthema* and *Ebussa*) and widespread as native or naturalized, especially in subtropical, tropical, warm-temperate, North and South America (Chen and Hind, 2011; Bogosavljević and Zlatković, 2015).

The section *Psilocarpaea* is the largest section in the genus *Bidens* L. *Psilocarpaea* taxa are very diverse in appearance, annual, to perennial; grasses or bushes, having simple and toothed to pinnatifid leaves. Capitula solitary, pedunculate, Flowers; radiate and discoid or discoid only. Achenes are more or less linear, flat, or tetragonal at the apex, muticus, or awned (Sherff, 1932; 1937).

*Bidens aurea* (Aiton) Sherff serves as the type of *Psilocarpaea* section, it is a central American species and introduced elsewhere, in recent years it became naturalized in southwest Europe (Sherff, 1932; 1937; Abdein and Al-Said, 2000; De Santayana *et al.*, 2005). Moreover, *Bidens aurea* was recorded in Arabia in Asir Mountains (Saudi Arabia), as a cultivated herb and often used as a tea substitute (Abdein and Al-Said, 2000). In 1997, J. R. I. Wood made several collections from the northern part of Yemen and he published his notes in "A handbook of the Yemen Flora" which remained the only flora of Yemen until 2013 where Al Khulaidi made a checklist on plants grown in Yemen (Flora of Yemen). Where he documented all the plants which were mentioned in previous floristic literature on Yemen.

A total of 2838 plant species including naturalized cultivated and alien plants have been reported from various habitats in Yemen

(Al Khulaidi, 2013), only three species of *Bidens*, belong to the section *Psilocarpaea*, namely *B. bipinnata* L., *B. biternata* (Lour.) Merr and *B. pilosa* L. were recorded in the flora of Yemen in general and in the flora of Sana'a city in particular (Dubie *et al.*, 1993; Dubie, 1995; Wood, 1997; Al Khulaidi, 2013; Ibrahim *et al.*, 2020).

During fieldwork, some naturalized peculiar populations of *Bidens* L. taxa were detected in Sana'a city. A primary taxonomical study was done to identify the observed *Bidens* taxa by comparing them with herbarium specimens mounted in the Herbarium of the Faculty of Science, Biology Department, Sana'a University. The investigation resulted that four *Bidens* taxa were grown in Sana'a city, three of the collected *Bidens* taxa specimens were similar to *Bidens bipinnata* L., *B. biternata* (Lour.) Merr and *B. pilosa* L. with few morphological differences.

After examining the morphological characters of the fourth collected *Bidens* taxon specimens carefully, and utilizing the available taxonomical and floristic literature, they were identified to be a new record for the genus *Bidens*, namely *B. aurea* (Aiton) Sherff. The present paper updates the information about the *Bidens* L. taxa grown in Yemen, new *Bidens* L. species to the flora of Yemen was reported, and a complete morphological description of the newly recorded species will be provided. Moreover, based on morphological leaf characters a comparison study and static analysis will be made to demonstrate the taxonomical relationship between the new recorded *Bidens* taxon and the closely related *Bidens* spp. recorded in the flora of Yemen.

## MATERIAL AND METHODS

During the period April to September 2019, a field survey was done on the genus *Bidens* L. in Sana'a city, four *Bidens* taxa were collected from different locations in Sana'a city (Table 1). Three of them were matched with the three recorded *Bidens* species in Yemen flora (*B. bipinnata*, *B. biternata* & *B. pilosa*) when compared with Herbarium specimens of *Bidens*

species kept at the Herbarium of the Biology Department Faculty of Science, Sana'a University (BHSS); *B. bipinnata* (BHSS 678), *B. biternata* (BHSS 692) and *B. pilosa* (BHSS 654). However, the fourth collected *Bidens* taxon was considered to be a new record to the flora of Yemen.

Based on the collected herbarium specimens (Table 1) and digital photos; a morphological description of the fourth collected *Bidens* taxon specimens were investigated by utilizing the available floristic (Collenette, 1999; Abedin and Al-Said, 2000; efloras. org, 2006) and taxonomic literature (Sherff, 1915; 1937). Moreover, based on the methodology and results cited by Ibrahim et al. (2020) with the terminology mentioned in the Manual of Leaf Architecture (Leaf Ar-

chitecture Working Group, 1999), a leaf morphological comparison was carried between the new record *Bidens* taxon and the closely related *Bidens* spp. mentioned in the Flora of Yemen by investigating 42 leaf morphological (26 qualitative and 16 quantitative) characters (Tables 2 and 3) cited by Ibrahim et al. (2020).

Furthermore, the taxonomical relationship (Dissimilarity) between the new record *Bidens* taxon and the closely related *Bidens* spp. cited in the flora of Yemen has been illustrated by a dendrogram. Based on the obtained leaf morphological (26 qualitative and 16 quantitative) characters a data matrix for numerical analysis (unweighted pair group mathematical average clustering – UPGMA) was created by Primer 5 software version: 5.2.2.

**Table 1.** Locations (coordinates and altitude), collection date and herbarium number of the Collected *Bidens* taxa.

Location	Date	Coordinates		Altitude	<i>Bidens</i> Taxal/ Herbarium No.
		Longitude	Latitude		
Near Hafsa school-Asser- Al-Wehdah District	11-4-019	44° 9'49.41"E	15°20'24.41"N	2426m asl.	<i>B. pilosa</i> (BHSS:1503)
Bestan Ali –Al-Tahreer District	26-4-019	44°11'40.58"E	15°21'16.39"N	2260masl.	<i>B. pilosa</i> ( BHSS:1508)
Nuqum area- Azal District	17-5-019	44°13'50.72"E	15°21'23.93"N	2634m asl	<i>B. bipinnata</i> ( BHSS:1514)
Al-Qaa Street- Al-Tahreer District	5-7-019	44°11'46.85"E	15°20'55.78"N	2262m asl.	<i>B. aurea</i> (BHSS: 1529)
Jawlat Sabaa- Shu'ub District	6-6-019	44°12'21.34"E	15°22'14.83"N	2248m asl.	<i>B. bipinnata</i> (BHSS:1520)
Al-Sabe'ein Park– Al- Sabe'ein District	18-7-019	44°12'9.97"E	15°19'36.84"N	2271m asl	<i>B. biternata</i> (BHSS:1532)
The New compos of Sana'a University-Maeen District	15-8-019	44°11'17.78"E	15°21'51.80"N	2262m asl.	<i>B. biternata</i> (BHSS:1540)
HaddahSakaniah, Al- Sabe'ein District	22-8-019	44°11'48.34"E	15°18'7.01"N	2301m asl	<i>B. aurea</i> (BHSS:1542)
Al- Dairy street-Maeen District	19-9-019	44°11'18.06"E	15°21'21.05"N	2270m asl	<i>B. aurea</i> (BHSS:1550)

**Table 2.** List of qualitative morphological leaf characters used in the comparison between *Bidens aurea* (Aiton) Sherff and the closely related *Bidens* spp. recorded in the Flora of Yemen.

Lamina	1/ Leaf arrangement	Opposite decussate [1]	Not so [2]
	2/ Leaf composition:	Simple [1]	Pinnatisect [2]
	3/ Orientation:	Apical [1]	Not so [2]
	4/ Lamina shape	Lanceolate - narrow ovate	Narrow ovate - very wide ovate

	(Form):	[1]	[2]	ovate [3]			
5/	Type of Lamina Area:	Microphyll [1]	Microphyll -Mesophyll [2]				
6/	Entire lamina balance:	Asymmetrical [1]	Not so [2]				
7/	Adaxial Surface	Glabrescent on vein islet and Pubescent on veins [1]	Pubescent on vein islet and Pubescent on veins [2]				
8/	Abaxial Surface	Glabrous on vein islet and Pubescent on veins [1]	Glabrous to Glabrescent on vein islet and Pubescent on veins [2]	Pubescent on veins islet and Pubescent on veins [3]			
9/	Adaxial Surface Color	Green to dark green [1]	Dark green [2]				
10/	Abaxial Surface Color	Light green [1]	Green [2]				
11/	Texture:	Coriaceous [1]	Chartaceous [2]				
12/	Venation:	Pinnate -Craspedodormous mixed [1]	Not so [2]				
13/	Lamina apex:	Acute-Mucronulate [1]	Acuminate -Mucronulate [2]				
14/	Lamina margin:	Serrate [1]	Serrate - Double serrate [2]				
15/	Lamina Margin Surface:	Glabrescent Ciliolate [1]	Pubescent Ciliolate [2]	Pubescent to villus Ciliolate [3]			
16/	Tooth spacing	Regular [1]	Irregular [2]				
17/	Tooth Sinus:	Angular [1]	Not so [2]				
18/	Tooth apex	Simple [1]	Acute-Mucronulate [2]				
19/	Lamina Base:	Decurrent [1]	Not so [2]				
20/	General shape & Cross-section	Inflated with a groove at the adaxial [1]	Not so [2]				
21/	Base	Swollen [1]	Not so [2]				
Petiole Characters	22/	Adaxial Surface Color	Red [1]	Red - reddish green [2]	Reddish green [3]	Light Green [4]	
	23/	Abaxial Surface Color	Green [1]	Green with red strips [2]	Green with reddish strips [3]		
	24/	Adaxial Surface	Glabrescent, grooved, with fimbria on the groove margin [1]	Glabrescent - Pubescent, grooved, with fimbriae on the groove margin [2]	Glabrescent - Pubescent, grooved, without fimbriae at the groove margin [3]	Pubescent, grooved, with fimbriae on the groove margin [4]	
	25/	Abaxial Surface	Glabrous [1]	Glabrous - Glabrescent [2]	Glabrescent - Pubescent [3]		
	26/	Position of petiole attachment	Marginal [1]	Not so [2]			

**Table 3.** List of quantitative morphological leaf characters used in the comparison between *Bidens aurea* (Aiton) Sherff and the closely related *Bidens* spp. recorded in the Flora of Yemen.

Sr. No.	Quantitative morphological leaf characters
1	Lamina length (mm)
2	Lamina width (mm)
3	Ratio L:W
4	Lamina size (mm <sup>2</sup> )
5	Leaf Area (mm <sup>2</sup> )
6	Petiole length (mm)
7	Leaf length (mm)
8	Leaf Size (mm <sup>2</sup> )
9	Apex Angle
10	Length of Lamina to total length of the leaf %
11	Length of petiole to total length of the leaf %
12	Length of petiole to Lamina length%
13	Total Number of Lobes
14	Size of Terminal lobe (mm <sup>2</sup> )
15	No. of Lateral lobes
16	Mean size of Lateral lobes (mm <sup>2</sup> )

## RESULTS

A field survey was done on the genus *Bidens* L. in Sana'a city, four *Bidens* taxa. were collected from different locations in Sana'a city. Three of them were matched with the three recorded *Bidens* spp. in the flora of Yemen; *B. bipinnata*, *B. biternata* & *B. pilosa*. However; the Morphological description of the fourth *Bidens* species was matched with *Bidens aurea* (Aiton) Sherff when compared with *Bidens* taxa mentioned in the available floristic and taxonomic literature.

### ***Bidens aurea* (Aiton) Sherff, Bot. Gaz. 59: 313 (1915).**

Synonym: *Coreopsis aurea* Dryand. ex Aiton (Bisonym); *Coreopsis ferulifolia* Jacq.; *Bidens heterophylla* Ortega; *Coreopsis lucida* Cav.; *Coreopsis nitida* hort.; *Bidens luxurians* Willd.; *Coreopsis trichosperma* var. *aurea* (Aiton) Nutt.; *Bidens arguta* Kunth; *Bidens decolorata* Kunth; *Coreopsis tetragona* Cerv.; *Kerneria ferulifolia* (Jacq.) Cass.; *Bidens arguta* var. *luxurians*

(Willd.) DC.; *Bidens ferulifolia* (Jacq.) DC.; *Bidens longifolia* DC.; *Bidens tetragona* (Cerv.) DC.; *Diodonta aurea* (Aiton) Nutt.; *Bidens warszewicziana* Regel; *Bidens warszewicziana* var. *pinnata* Regel; *Bidens heterophylla* var. *wrightii* A. Gray & *Bidens aurea* var. *wrightii* (A. Gray) Sherff Annual to perennial, erect, 56-160 cm tall, herb (Figure 1 A&B ) Leaves petiolated; Petioles green, 8.6-37mm long, pubescent, grooved with fimbriae on the groove margin at the adaxial surface, glabrous at the abaxial surface. Blades, lanceolate to narrow ovate, 39.8-98.2 × 11.7-30.7 mm, asymmetrical, microphyll, chartaceous, adaxial surface; dark green, glabrescent on vein islet and pubescent on veins, abaxial surface; light green, pubescent on vein islet and veins; pinnate - Craspedodormous mixed venation, acuminate -mucronulate apex, double serrate, glabrescent ciliolate margin, decurrent asymmetrical base (Figure 1 C&D). Capitulate radiate 5.6-14.3× 2.6-5.1 mm with diameter; 3.9-5.3mm (Figure 1 E & F), pedunculate. Peduncles 15-124mm long (Figure 1 G). Outer involucral bracts; 8-10, 1.7-3.2 × 0.5-0.7 mm, green, glabrous to glabrescent on the upper and lower surface with a lathery pubescent margin (Figure 1H). Middle involucral bracts; 3.3-5.2×0.9-1.5, yellowish with brown color along the central longitudinal axis of the bract, membranes with a villous tip (Figure 1I). Inner involucral bracts; 2.9-4.6×0.6-1mm, yellowish with brown color along the central longitudinal axis of the bract, membranous with a glabrous tip (Figure 1J). Ray florets; 4-5; 5.7-10.8×2.7-7.5 laminae yellow with white patches; corolla with 3 lobes (Figure 1K).

**Table 4.** Comparison of diagnostic Qualitative and Quantitative leaf morphological characters of *Bidens aurea* (Aiton) Sherff with its closely related *Bidens* species cited in the Flora of Yemen.

Leaf Characters	<i>B. aurea</i>	<i>B. bipinnata</i> *	<i>B. biternata</i> *	<i>B. pilosa</i> *
1/ Leaf arrangement:	Opposite (decussate)	Opposite (decussate)	Opposite (decussate)	Opposite (decussate)
2/ Leaf composition:	Simple	Pinnatisect	Pinnatisect	Pinnatisect
3/ Orientation:	Apical	Apical	Apical	Apical
4/ Shape (Form):	Lanceolate - narrow ovate	Narrow ovate - very wide ovate	Narrow ovate - very wide ovate	Ovate - very wide ovate
5/ Type of Lamina area:	Microphyll	Microphyll -Mesophyll	Microphyll -Mesophyll	Microphyll -Mesophyll
6/ Entire lamina balance:	Asymmetrical	Asymmetrical	Asymmetrical	Asymmetrical
7/ Adaxial surface:	Glabrescent on vein islet and Pubescent on veins	Glabrescent on vein islet and Pubescent on veins	Pubescent on vein islet and Pubescent on veins	Glabrescent on vein islet and Pubescent on veins
8/ Abaxial surface:	Pubescent on veins islet and Pubescent on veins	Glabrous on vein islet and Pubescent on veins	Glabrous on vein islet and Pubescent on veins	Glabrous to Glabrescent on vein islet and Pubescent on veins
9/ Adaxial surface color:	Green to dark green	Dark green	Green to dark green	Dark green
10/ Abaxial surface color:	Light green	Green	Green	Green
11/ Texture:	Chartaceous	Coriaceous	Chartaceous	Coriaceous
12/ Venation:	Pinnate - Craspedodormous mixed	Pinnate – Craspedodormous mixed	Pinnate – Craspedodormous mixed	Pinnate -Craspedodormous mixed
13/ Lamina apex:	Acuminate – Mucronulate	Acute- Mucronulate	Acuminate - Mucronulate	Acute- Mucronulate
14/ Lamina margin:	Serrate - Double serrate	Serrate	Serrate	Serrate
15/ Margin surface	Glabrescent Ciliolate	Pubescent to villus ciliolate	Pubescent Ciliolate	Glabrescent Ciliolate

Qualitative Characters of Entire Lamina

	16/ Tooth spacing	Irregular	Irregular	regular	regular
	17/ Tooth sinus:	Angular	Angular	Angular	Angular
	18/ Tooth apex:	Simple	Acute-Mucronulate	Acute-Mucronulate	Acute-Mucronulate
	19/ Lamina Base:	Decurent	Decurent	Decurent	Decurent
Qualitative Characters of Petiole	20/ General shape & Cross-section:	Inflated with a groove at the adaxial	Inflated with a groove at the adaxial	Inflated with a groove at the adaxial	Inflated with a groove at the adaxial
	21/ Base:	Swollen	Swollen	Swollen	Swollen
	22/ Adaxial surface color:	Light Green	Reddish-green	Red to reddish-green	Red
	23/ Abaxial surface color:	Green	Green with reddish stripes	Green with red stripes	Green with red stripes
	24/ Adaxial surface	Pubescent, grooved, with fimbriellae on the groove margin	Glabrescent, grooved, with fimbrella on the groove margin	Glabrescent - Pubescent, grooved, with fimbriellae on the groove margin	Glabrescent - Pubescent, grooved, without fimbriellae at the groove margin
	25/ Abaxial Surface	Glabrous	Glabrous – Glabrescent	Glabrous – Glabrescent	Glabrescent – Pubescent
	26/ Position of petiole attachment:	Marginal	Marginal	Marginal	Marginal
Quantitative Characters of Entire Lamina & Petiole	1/ Lamina length (mm) Min (Mean ±SD) Max	39.8 (62.4±14.9) 98.2	33(75.2±21.7)138	43(77.2±12.1)101.9	28.1(67.4±20.3)119.7
	2/ Lamina width (mm) Min (Mean ±SD) Max	11.7 (18.2± 4.1) 30.7	29.2(69.2±21.4) 122.6	25.6 (73 ±16.8) 107.9	24.6(70.3±23.3)119.8
	3/ Ratio L:W	2.4(3.5 ±0.6) 6.7	0.8(1.1±0.2) 2.7	0.8(1.1±0.2)1.7	0.7(1±0.2) 1.5
	4/ Lamina size (mm <sup>2</sup> ) Min (Mean ±SD) Max	502.5 (1180.6± 543.7) 3008.9	962.5 (5606.5±3356.7) 16912.2	1100.8 (5804.5±1983.7) 10524.2	832 (5176 ±3074.2) 14342.9
	5/ Leaf Area (mm <sup>2</sup> ) Min (Mean ±SD) Max	335 ( 787.1±362.5) 2005.9	641.7 (3737.7±2237.8) 11274.8	733.9 (3869.6±1322.5) 7016.2	554.7(3450.7±2049.5) 9562
	6/ Petiole length (mm) Min (Mean ±SD) Max	8.6 ( 19.2 ±5.5) 37	6.02 (33±16.8) 73.9	12.6 (29.5±8.9)53.6	5 (22.5±10.4) 47.2
	7/ Leaf length (mm) Min (Mean ±SD) Max	53.2 (81.5± 17.3)125.3	40.6(108.1±35.3) 195.4	55.6(106.7±18.6)148.4	48.2(89.9±26.1)151.9
	8/ Leaf Size (mm <sup>2</sup> ) Min (Mean ±SD) Max	692.3 (1539.3±677.9) 3841.2	1186.8 (8123±5076.7) 23949	1421.9 (8048±2895) 16008.2	1183.7 (6873.5±4012.2) 18192.3
	9/ Apex Angle	21.4 (39.2 ± 6.1)53.1	29.3 (46.1±9.9)74.5	24.1 (42.3±10.5) 66.4	28.4(66.7±15.4) 98.7

	Min (Mean ±SD) Max				
10/	Length of Lamina to total length of the leaf % Min (Mean ±SD) Max	7.4(67.8 ±22.7)110.1	52 (71 ±8.2) 88	60.2(72.8±4.8)80.2	51.5 (75.2±8.6)93.4
11/	Length of petiole to total length of the leaf % Min (Mean ±SD) Max	9.8(23.8 ± 5.2 )33.9	12 (29±8.2) 48	19.8 (27.2±4.8) 39.8	6.6 (24.8±8.6)48.6
12/	Length of petiole to Lamina length% Min (Mean ±SD) Max	10.8 (31.7 ±8.6) 51.2	13.7(42.8±17.5)92.5	24.7(38 ±9.6)66	7.1(34.9± 16.8)94.4
13/	Total Number of Lobes Min (Mean ±SD) Max	0	3 (6± 1.1)9	3(3±0.4)5	3
14/	Size of Terminal lobe (mm <sup>2</sup> ) Min (Mean ±SD) Max	0	101.7 (818.9±435.3 ) 2077	652 (2097.9±607) 3615.6	446.7 (2223.2 ±1244.1) 6113
15	No. of Lateral lobes Min (Mean ±SD) Max	0	2 (5±1.1)8	2(2 ±0.4) 4	2
16/	Mean size of Lateral lobes Min (Mean ±SD) Max(mm	0	97.7(658.9±397.8) 1988.8	154.2 (776.8±275.5) 1521.7	151.4 (888.8 ±518.7) 2423.9

\*Qualitative and Quantitative leaf characters of *Bidens* spp. (*B. bipinnata*, *B. biternata* & *B. pilosa*) recorded by Ibrahim et al. (2020).



**Table 5.** Data Matrix of the Qualitative leaf Morphological characters.

Leaf quantitative Characters		<i>B. aurea</i>	<i>B. bipinnata</i>	<i>B. biternata</i>	<i>B. pilosa</i>
Entire Lamina	1/ Leaf arrangement:	1	1	1	1
	2/ Leaf composition:	1	2	2	2
	3/ Orientation:	1	1	1	1
	4/ Shape (Form):	1	2	2	3
	5/ Type of Lamina area:	1	2	2	2
	6/ Entire lamina balance:	1	1	1	1
	7/ Adaxial surface:	1	1	2	1
	8/ Abaxial surface:	3	1	1	2
	9/ Adaxial surface color:	1	2	1	2
	10/ Abaxial surface color:	1	2	2	2
	11/ Texture:	2	1	2	1
	12/ Venation:	1	1	1	1
	13/ Lamina apex:	2	1	2	1
	14/ Lamina margin:	2	1	1	1
	15/ Margin surface	1	3	2	1
	16/ Tooth spacing	2	2	1	1
	17/ Tooth sinus:	1	1	1	1
	18/ Tooth apex:	1	2	2	2
	19/ Lamina Base:	1	1	1	1
Petiole	20/ General shape	1	1	1	1
	21/ Petiole base	1	1	1	1
	22/ Adaxial surface color	4	3	2	1
	23/ Abaxial surface color	1	3	2	2
	24/ Adaxial surface	4	1	2	3
	25/ Abaxial surface	1	2	2	3
	26/ Position of petiole attachment	1	1	1	1

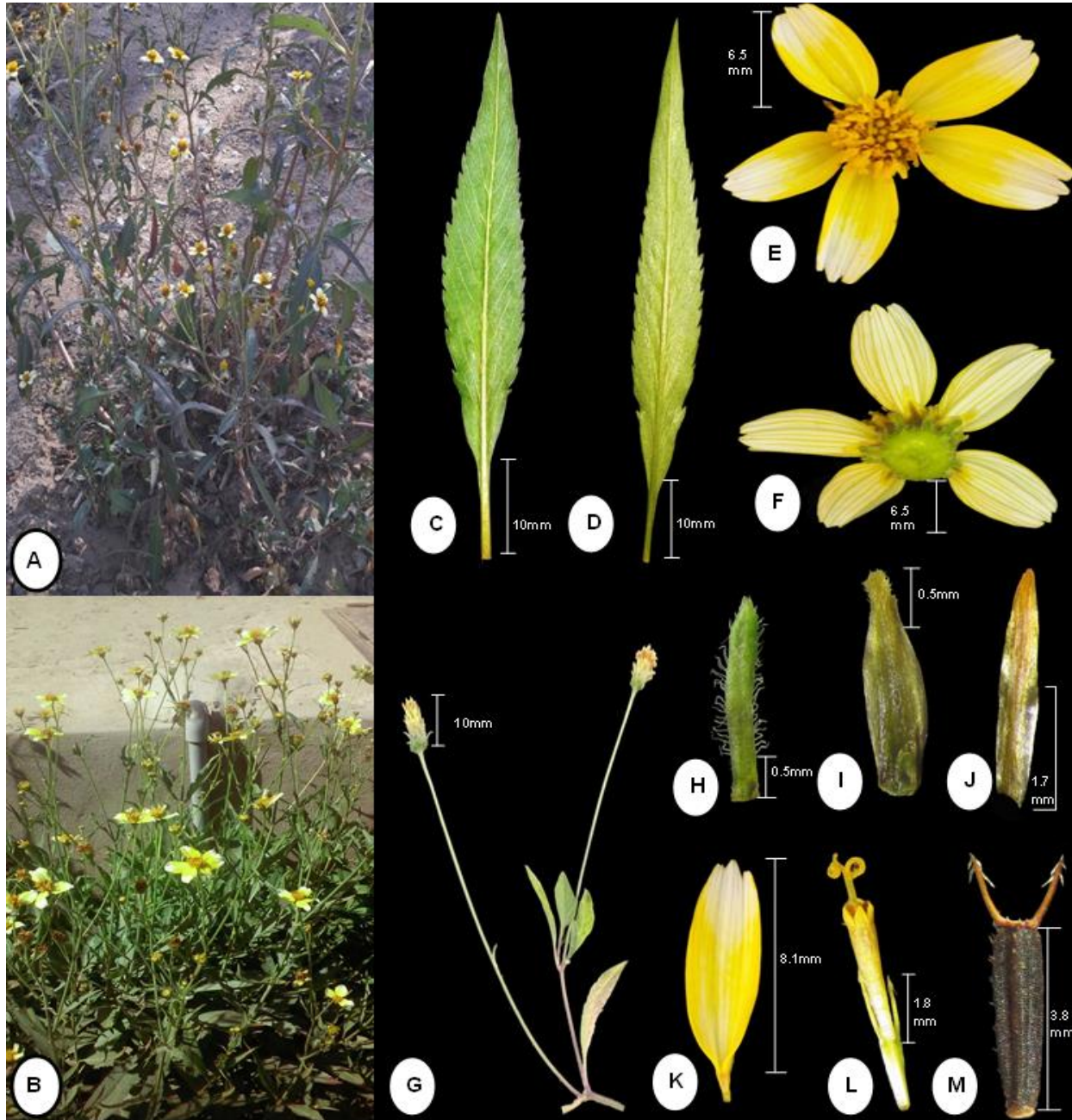
Discoid florets; 29-50; 4.2-6.7 × 0.5-1 mm, corollas yellowish, 2.5- 3.5mm long with 5 lobes (Figure 1L), Achene (cypsela); 4.1 - 5.8 mm long (excluding the length of the awn) and 0.72-0.82 mm width, dark brown to blackish, ± flattened; papillose at base; apices truncate 0.21-0.28mm in diameter, carrying two awns; 1.5- 2 mm long, with 2-5 erect to spreading 0.2-0.3mm long, retrorsely barbed awns (Figure 1M).

According to table 4, nine qualitative leaf morphological characters; leaf arrangement, leaf orientation, entire lamina balance, leaf venation, marginal tooth sinus, lamina base, general

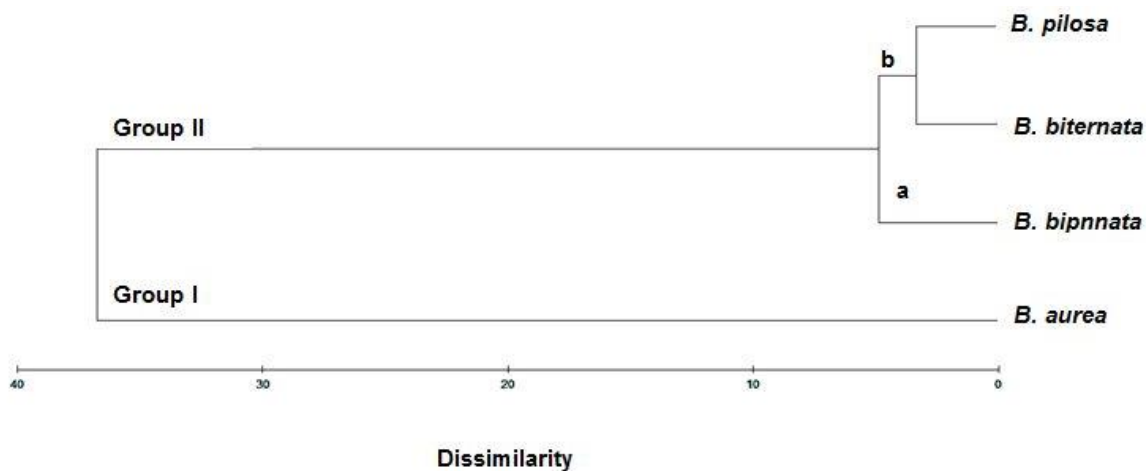
shape of the petiole, petiole base and position of petiole attachment; showed a similarity between *Bidens aurea* and the other three recorded *Bidens* species; *B. bipinnata*, *B. biternata* and *B. pilosa*. Moreover, based on 42 leaf morphological features (26 qualitative and 16 quantitative), the dendrogram (Figure 2) resulting from the UPGMA method illustrates the relationship among the new recorded *Bidens* taxon and the closely related *Bidens* taxa recorded in the Flora of Yemen and divides them into two groups (I&II) at distance level 36.67, the first group includes *Bidens aurea* which characterized by simple lanceolated to narrow ovate leaves, serrate - double serrate margin and

simple tooth apex, lamina is microphyll, the abaxial surface of the lamina is light green in color, pubescent on veins islet and pubescent on veins. Moreover, the adaxial leaf petiole surface in *Bidens aurea* leaf is light green, pubescent,

grooved, with fimbriae on the groove margin, while, the abaxial leaf petiole surface is green and glabrous.



**Fig. 1.** Morphology of *Bidens aurea* (Aiton) Sherff: A-B: General view, C: Adaxial leaf view, D: Abaxial leaf view, E- F: Radiate Capitulate; E: upper view, F: lower view, G: Inflorescence peduncles, H- J: Involucral bract; H: Outer involucral bract, I: Middle involucral bracts, J: Inner involucral bract, K: Ray florets, L: Discoid florets, M: Achene (cypselae).



**Fig. 2.** Cluster analysis illustrates the relationship between *Bidens aurea* and the other three *Bidens* spp. cited in the flora of Yemen based on 42 morphological leaf Characters (26 qualitative characters and 16 quantitative characters) by using the UPGMA method.

However, the second group includes the other three *Bidens* species (*B. bipinnata*, *B. biternata* and *B. pilosa*) which are characterized by microphyll - mesophyll, green lamina abaxial surface, serrate at the margin, and pinnatisect leaf. Furthermore, the second group was divided into two subgroups (a&b) at distance level 4.91. The first subgroup includes *B. bipinnata*, while, the second subgroup includes *B. biternata* and *B. pilosa* which were separated at distance level 3.35.

## DISCUSSION

The leaf Morphological characters in table 4 show the strong affinity of the species in the section level; the qualitative leaf morphological characters were more or less the same in *Bidens aurea* (new record to the flora of Yemen) and the three closely related *Bidens* species (*B.*

*bipinnata*, *B. biternata* & *B. pilosa*) mentioned in the flora of Yemen (Wood, 1997; Al Khulaidi, 2013; Ibrahim *et al.*, 2020). However; some of those characters might show an important taxonomic value in differentiating between *Bidens aurea* and the other three *Bidens* species; leaf composition and shape, type of lamina area, abaxial lamina surface type and color, type of lamina margin and tooth apex, type and color of adaxial leaf petiole surface, type and color of abaxial leaf petiole surface. Moreover; nine quantitative morphological characters (lamina width, the ratio of lamina length to width, lamina size, leaf area, leaf size, total number of lobes, size of the terminal lobe, number of lateral lobes & mean size of lateral lobes) were mentioned in table 4 shows a taxonomic significant in *Bidens aurea* from the other three *Bidens* spp.

## CONCLUSION

New species belongs to the genus *Bidens*; *Bidens aurea* (Aiton) Sherff has been recorded on the territory of Yemen, 9 qualitative leaf morphological characters show a similarity between the new recorded *Bidens* taxon and the closely related *Bidens* taxa cited in the flora of Yemen. However 11 qualitative leaf morphological characters; leaf composition and shape, type of lamina area, abaxial lamina surface type and color, type of lamina margin and tooth apex, type and color of adaxial leaf petiole surface, type and color of abaxial leaf petiole surface and 9 leaf morphological characters (Lamina width, Ratio of lamina length to width, Lamina size, Leaf area, Leaf size, Total number of lobes, Size of the terminal lobe, Number of lateral lobes and Mean size of lateral lobes) shows an important taxonomic value in differentiating between *Bidens aurea* and the other three *Bidens* species recorded in the flora of Yemen.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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