

IUCN SSC Freshwater Plant Specialist Group

THE CONSERVATION STATUS OF *CALLITRICHE MATHEZII* SCHOSTM.

September 2019



by

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Cover images:

Above: The survey team celebrating rediscovery of *Callitriche mathezii* and Oulmès with tea and
“Corne de gazelles” pastries

Below: *Callitriche mathezii*, predominantly female plant, Oulmès

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Contents

EXECUTIVE SUMMARY	I
1 INTRODUCTION	1
Acknowledgements	1
2 RESULTS	3
2.1 Morphology of <i>Callitriche mathezii</i>	3
2.2 Distribution of <i>Callitriche mathezii</i>	6
2.2 Ecology of <i>Callitriche mathezii</i>	7
2.2.1 General principles	7
2.2.2 Cupular pools	8
2.2.3 Seasonal pools on silt or clay	9
2.2.4 Seasonal pools in rocky desertic habitats at high altitude.	9
3 CONCLUSIONS	11
REFERENCES	13
APPENDIX: SITE DATA	15
28th April 2019	15
1. Mar de Tiflet	15
2. Stream upstream of the dam	15
3. Seasonal pools near Oulmès	16
4. Stream near Hotel des Thermes	19
5. Pools in granite outcrops near the Hotel des Thermes	19
6. Flushes on hill slopes near the Hotel des Thermes	20
30th April 2019	20
7. River near Oulmès	20
8. Sidi Mrahe stream	21
9. Wetland complex at Mante	21
10. Cupular pools in granite near Mante	22
11. Mar de Arbassine	23
12. Stream Tna Ounahal	24
1st May 2019	25
13. Akzou	25
2nd May 2019	26
14. Seasonal lakes between Azrou and Timahdite (Jbel Hebri)	26
3rd May 2019	29
15. Seasonal pools near Azrou	29
10th June 2019	30
16. Aguelmam Afennourir	30

EXECUTIVE SUMMARY

This report describes work undertaken to provide up to date information on the current distribution and conservation status of Mathez's water-starwort (*Callitriche mathezii*). All sites for which there were records (except south-west of Tetouan), as well as a range of other wetlands in the area east from Rabat to the plateau of the Moyen Atlas around Timahdit. Prior to this survey, *C. mathezii* had been reported from four sites: Central Plateau. Akzou (Agziou), south-west of Aguelmous and of Jbel Mtourzgane (Torziane), Oulmès, between Tiflet and Maaziz and SW of Tetouan. The origins of the records from between Tiflet and Maaziz and SW of Tetouan are unclear and unless material from this region can be confirmed, it is probably best to dismiss this record.

During this project, *C. mathezii* was found in a total of seven main areas, three (Oulmès, Aguelmous - Mante and Aguelmous - Akzou) on the Central Plateau and four (Aguelmam Afennourir and sites between Jbel Hebri and Timahdite) in the Moyen Atlas. It must therefore be considered endemic to a very small area of Morocco. *C. mathezii* appears to be fairly abundant within a limited area, however the vulnerability of many of the sites where it occurs, combined with the limited number of sites and extremely restricted range mean that it should still be classed as Endangered.

Biometric data collected on fresh material show that the taxon treated as *C. mathezii* includes significant variation, which in other members of the genus could justify it being split into at least two taxa. This can only be resolved through further morphological and molecular research. This work has also confirmed that *C. mathezii* is capable of persisting in a terrestrial form and appears to be able to undergo fertilisation under water.

C. mathezii was recorded in four main habitat types: cupular pools in rock outcrops, seasonal pools on soil at medium altitude, seasonal pools in rocky desertic habitats at high altitude and a stream flowing over soil. It occurred in a wide range of habitats but notably did not occur in permanent water bodies. In each habitat it occurred with a different range of species, with no associates occurring in all the habitats.

1 INTRODUCTION

Between 2015 and 2018, with funding from Mohamed Bin Zayed Species Conservation Fund (MBZ), R.V. Lansdown reviewed the conservation status and requirements of all known *Callitriche* species (Lansdown 2015), through which the need for survey of Mathez's water-starwort (*Callitriche mathezii*) to inform conservation was recognized as a priority. As part of projects to evaluate the conservation status of wetlands through Africa (Darwall *et al.* 2011) and in North Africa (García *et al.* 2010), a Red List assessment was prepared for *C. mathezii* in which it was classed as globally Endangered (Rhazi and Grillas 2010). This report describes work undertaken to provide up to date information on the current distribution and conservation status of *C. mathezii*. Funds from the MBZ enabled surveys of all sites for which there were records (except south-west of Tetouan, see below), as well as a range of other wetlands in the area east from Rabat to the plateau of the Moyen Atlas around Timahdit. In addition to searches for *C. mathezii*, data were collected on the wetland-dependent plant species in each site visited, together with notes on the condition and threats to sites. The main body of the report describes *C. mathezii*, its ecology and conservation status, while details of the sites visited are included as an appendix.

C. mathezii was first recognised when Joel Mathez sent material of an unidentified *Callitriche* collected from near Jbel Mtourzgan in Morocco to H.D. Schotsman (J. Mathez pers. comm. to P. Grillas) who was at the time based at the Museum National d'Histoire Naturel, Paris and studying the genus. Schotsman recognised that this material represented a previously undescribed species and named it in honour of its finder (Schotsman 1976). Subsequent review of herbarium material and the literature revealed a total of four reports of the species, including the type locality:

- Central Plateau. Akzou (Agziou), col 65 km south-west of Aguelmous and 3 km south-west of Jbel Mtourzgan (Torziane), 1,562 m alt., 2 May 1970, *J. Mathez 55078* (holotype: MPU 310674, isotype RAB 085553) (Schotsman 1976, Fennane and Ibn Tattou 1998, Fennane *et al.* 1999, Hammada *et al.* 2002).
- Oulmès, 1200 m alt., Emberger (RAB 13821) (Schotsman 1976) mixed with *C. brutia*.
- Between Tiflet and Maaziz, undated (Fennane *et al.* 1999).
- SW of Tetouan, undated (Fennane *et al.* 1999).

The origins of the records from between Tiflet and Maaziz and SW of Tetouan are unclear. They are not supported by specimens in Rabat or elsewhere and there appear to be no literature references to these records which are not based on Fennane *et al.* (1999), unless material from this region can be confirmed, it is probably best to dismiss these records. During other research starting in the mid-1990s, *Callitriche* specimens in the following herbaria have been reviewed (AD, ALA, ANSP, ASE, ATHU, BM, BOL, BR, BRI, BSB, BUNS, C, CANB, CGE, CHR, E, EAC, EFC, F, FI, FLOR, FT, FURB, G, GB, GH, GOET, HAST, HBR, HIB, HO, HRB, HUA, HURB, JEPS, K, L, LE, LINN, LIV, MA, MBM, MEL, MICH, MO, NAS, NMW, NSW, NU, NY, ORE, P, PA, PE, PH, PP, PRE, RNG, SEV, SI, STU, TAI, TAIF, TAMU, TEPB, TNM, TNU, TRE, TUB, UAM, UBC, UC, UESC, UPS, US, V and WTU (acronyms according to Thiers 2019). Review of *Callitriche* specimens in 78 herbaria has revealed no other material and it appears likely that *C. mathezii* is endemic to the Central Plain and Moyen Atlas of Morocco. No *Callitriche* material from Algeria has been seen and the possibility that it occurs there cannot be dismissed.

In May 2019, after completion of the fieldwork for this project, more than twenty wetland sites in the Sebou catchment were surveyed for a project to validate the Sebou Catchment Key Biodiversity Area. *C. mathezii* was found at one of these sites and the data from that site are included in this report.

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2 RESULTS

2.1 Morphology of *Callitriche mathezii*

Based on review of herbarium material, Schotsman (1976) provided the following description of the morphology of *C. mathezii* (translated by R.V. Lansdown):

Stems narrow, to a few centimetres long, with [scales] mainly in the upper part. Stem [scales] often asymmetrical, generally composed of (8)-12-16-(20) cells. All leaves expanded; leaves show different forms, on one stem one can see subcircular, sub-rhomboidal, obovoid, flattened or wedge-shaped leaves; in the last two cases the limb is wider than long; the petiole is as long as or longer than the blade, often wedge-shaped and in which case, significantly wider near the blade than the base; sometimes the blade narrows abruptly into a narrow petiole of equal length throughout; total length 3-5mm; blade 1-2mm long; 2-2.5mm wide; petiole 0.5mm wide (at base) - 1mm near blade; rosettes are very small, 5-7mm wide, with 8-12 leaves. Venation: simple, on the main nerve at the point where the blade widens, a nerve detaches on the left and right, running more or less parallel with the leaf edge; these nerves re-join the main nerve below the apex; often on each of these nerves (2) a smaller nerve departs and re-joins between nerve 2 and the border; in addition, there may be one or two small, free nerves. Leaf [scales] disk 4-8 cells. Axillary [scales]: with 4 digitate cells, generally in a single plane. Flowers: solitary, emerging over the rosette on flowering; some rosettes have only ♂, some only ♀ flowers, on these rosettes, one can find 6-8 consecutive pairs of leaves which have a flower of the same sex in each axil, quasi-dioecious. Bracteoles large, lanceolate, pointed at tip, 1-1.5mm long. Stigma/style: styles erect or slightly divergent to 2-3mm long. Stamen initially erect, after dehiscence, they lengthen and often collapse, up to 3-4mm long. Anther voluminous in comparison to the reduced size of the leaves, at dehiscence 0.5-0.8mm wide. Pollen: subspherical, yellow. Fruit subsessile or shortly pedunculate, slightly higher than wide from the side, elliptic 1.3-1.5mm high, 1-1.2mm wide, small remainders of styles erect; the commissural wall is deep and wide; the sides of the fruit are flattened, but at the base the ventral part of the mericarp curves gently outward. Ripe mericarps are dark brown and the wing is paler. Wing broad, clearly wider on the lower part of the ventral side of the mericarp. No. of chromosomes: $2N = 10$.

Schotsman (1976) concluded that it was incapable of developing a terrestrial form. Data collected through this project have shown that *C. mathezii* can persist as a terrestrial form with expanded leaves on damp mud (Figure 2.6), as well as in a very reduced form with linear leaves (Figure 2.5) on the draw-down zone of a large seasonal lake.

Schotsman (1976) also noted a degree of difference between populations from Akzou and Oulmès, data collected for this project have enabled more detailed information on these differences.

- Biometric data (Fig. 2.1) show that fruit from Jbel Hebri are consistently smaller than those from the two other areas.

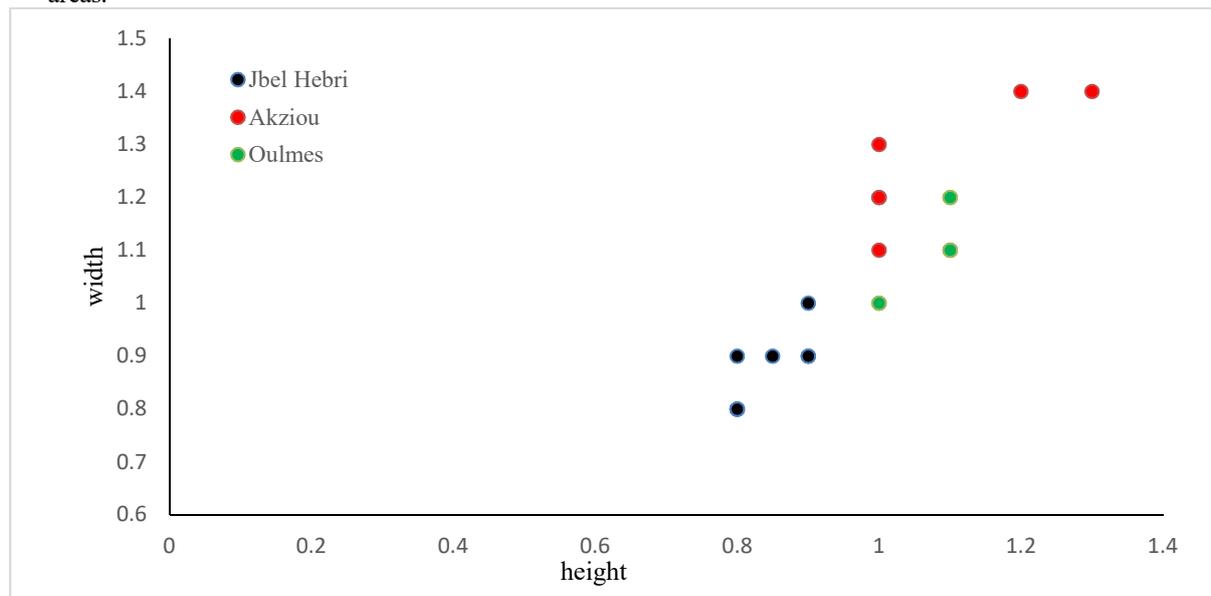


Figure 2.1 Fruit biometrics from three sites

- Figure 2.2 shows that fruit of the plants from Akzou and Jbel Hebri appear to be higher than wide, whilst fruit from Oulmès appears wider than high, however neither of these impressions is borne out by biometric data (Fig. 2.2). The nature and extent of the wing appears to differ consistently with these differences.



Figure 2.2 Fruit of *C. mathezii*: left - Akzou; centre - Oulmès; right - Jbel Hebri

- Plants from Oulmès and Akzou were almost entirely dioicous, whereas plants from Jbel Hebri had female flowers toward the base of shoots and male toward the apex, suggesting that female flowers develop first and then male.

Without more detailed research supported by molecular analysis, it is not possible to assess whether these differences are sufficiently significant to justify taxonomic distinction or whether *C. mathezii* is simply an extremely variable species. However, differences such as these have been treated as taxonomically significant in other areas e.g. recognition of subspecies within *C. heterophylla* (Fassett 1951).



Figure 2.3 Almost entirely female plant of *C. mathezii*, Oulmès



Figure 2.4 Almost entirely male plant of *C. mathezii*, Oulmès



Figure 2.5 Terrestrial plant of *C. mathezii* (Jbel Hebri) showing the large anthers but both male and female flowers

Biometric data collected on fresh material allows development of the following standardised description of *C. mathezii*:

Stem and leaf scales present. Leaf bases connate. Lingulate leaves unknown, expanded submerged or floating leaves typically with a long petiole terminated by a small, very broad blade $1.2-3.3 \times 0.5-2.2$ mm, petiole $0.6-5.1$ mm, venation simple or complex with numerous loops and anastomosing veins, the apical leaves forming a floating rosette, leaves of terrestrial plants narrowly elliptic $1.6-2.5 \times 0.2-0.9$ mm. Flowers solitary, usually predominantly one gender on a shoot or even entire plant. Bracts falcate, persistent $0.5-0.9$ mm. Styles erect, becoming recurved in fruit, ≤ 4.1 mm. Filaments erect ≤ 3.5 mm; anthers reniform, $0.4-0.6$ mm diameter; pollen yellow. Fruit not strumose, sessile or pedicellate to 10.8 mm, \pm as wide as high, blackish when mature, contrasting with pale wing, $0.8-1.3 \times 0.8-1.4$ mm, wing throughout



Figure 2.6 Predominantly male plant of *C. mathezii*, Oulmès, showing the large and prominent anthers



Figure 2.7 Submerged plant of *C. mathezii* near Timahdite, showing the long-pedunculate fruit, as well as both dehiscent and un-dehiscent anthers

2.2 Distribution of *Callitriche mathezii*

C. mathezii was found in a total of seven main areas (Figure 2.8), three (Oulmès, Aguelmous - Mante and Aguelmous - Akzou) on the Central Plateau and four (Aguelmam Afennourir and sites between Jbel Hebri and Timahdite) in the Moyen Atlas. Previous reports that were supported by vouchers are all from the Central Plateau and therefore, these

new records can be seen not only to represent the first records of this species in nearly fifty years, but a significant addition to the known range of the species. However, if the report from south-west of Tetouan is dismissed (until or unless it can be confirmed) all known sites for this species lie within 100 km of each other. It must therefore be considered endemic to a very small area of Morocco.



Figure 2.8 Known distribution of *Callitriche mathezii*

Employing the concepts of Extent of Occupation (EOO) and Area of Occupancy (AOO) employed by IUCN (IUCN 2012), *C. mathezii* must still be classed as Endangered as it has an EOO of 1,576.995 km², an AOO of 32.000 km² and all the sites where it occurs are threatened by factors such as agricultural intensification, over-exploitation (e.g. by stock) and over-grazing (Lansdown, Rhazi and Grillas in press).

2.2 Ecology of *Callitriche mathezii*

2.2.1 General principles

C. mathezii was recorded in four main habitat types:

- Cupular pools in rock outcrops.
- Seasonal pools on soil at medium altitude.
- Seasonal pools in rocky desertic habitats at high altitude.
- A seasonal stream flowing over soil.

It occurred in a wide range of habitats but notably did not occur in permanent water bodies. In each habitat it occurred with a different range of species, with no associates occurring in all the habitats.

Table 2.1 Water quality at sites supporting *Callitriche mathezii*

Site	Alt. (m)	Oxygen (mg/l)	pH	Conductivity (µS)	T° (°C)	Turbidity	Chlorophyll A	cyano-bacteria
Seasonal pool, Oulmès	1169	2.4	7.22	332	24.05	8.55	39.18	37.31
Stream, Oulmès	1170	5.37	7.35	159	28.6	3.12	23.21	15.5
cupular pool, Mante	1163	5.47	7.43	754	22.94	5.256	76.59	295.8
cupular pool, Akzou	1250	8.45	10.49	160	21.55	6.77	58.54	43.45

cupular pool, Akzou	1433	8.62	10.57	213	23.64	17.26	1896	308.3
Lake 1, Jbel Hebri	1928	5.302	8.27	64	21.14	197.2	121.1	174.8
Lake 2, Jbel Hebri	1895	6.11	10.07	64	15.28	102.9	139.9	177.1
Near Timahdit	1912	5.76	9.73	134	16.9	12.08	121.1	85.92

The high pH values are probably a result of photosynthesis rather than from the presence of calcium. This is shown by the correlation between O₂ and pH (Figure 2.9) and further indicated by the low conductivity.

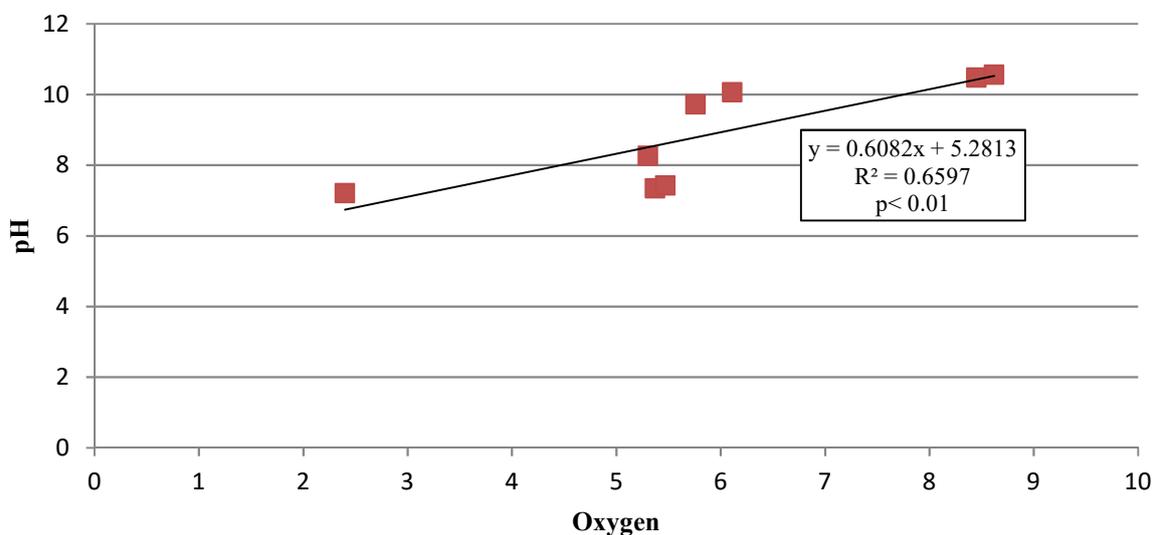


Figure 2.9 Graph showing the relationship between Oxygen levels and pH of the water

2.2.2 Cupular pools

The cupular pools found during this survey typically involved small, rain-filled hollows in level bedrock, where the water is generally less than 0.5 m deep and lasts for only a few months at a time. Each pool supports only a very small number of species (Table 2.2) and it is not unusual for a pool to be dominated by a single species. *Crassula vaillantii* is one of the most frequent species in such pools throughout the Mediterranean and much of Africa and it is not surprising that it was recorded with *C. mathezii*. Other species recorded with *C. mathezii*, in addition to those listed in Table 2.2, include *Sedum jahandezii*, *S. andegavense*, and *Paronychia echinulata* (J. Mathez in litt. to H.D. Schotsman).

Table 2.2 Species recorded in rock pools supporting *C. mathezii*

	Aguelmous (Mante)			Aguelmous (Akzou)		
	1	2	5	6	7	9
	Quadrat					
	9	10	11	12	13	14
<i>Callitriche mathezii</i>	80	5	25	5	10	15
<i>Crassula vaillantii</i>		30		25		
<i>Pulicaria arabica</i>		15				
<i>Isoetes velata</i>		15				
<i>Callitriche stagnalis</i>				5		

Mathez provided a detailed description of the type locality for *C. mathezii*, as follows: “Akzou (Agziou) a peak rising to 1,562 m. The site with *Callitriche* is on a col characterised by horizontal quartzite sheets, situated at 1486 m altitude at the foot of a south-east facing slope below this crest approximately 6.5 km south-west of Aguelmous and 3 km south-west of Jbel Mtourzgane (Torziane) at the final point of the Central Plateau. Horizontal quartzite exposures are very unusual in the region, it is more normal for quartzite exposures to form raised peaks and cliffs. In places on these quartzite beds there are small pools a few tens of centimetres in diameter and a few centimetres deep where rainfall

accumulates and why dry out in summer. At the time that the *Callitriche* was collected, these pools still held water and were covered by a dense carpet of drying *Callitriche*. The *Callitriche* occupied the centre of the hollows and on the margins was mixed with *Crassula vaillantii*, *Sedum jahandezii*, *S. andegavense* and *Paronychia echinulata*, species which also grow in ephemeral pools on sandstone rocks. The site is surrounded by evergreen oak woodland” (Schotsman 1976) (translated by R.V. Lansdown).

2.2.3 Seasonal pools on silt or clay

C. mathezii was recorded from two wetlands along a shallow valley surrounded by arable to the east of the town of Oulmès (Appendix A3). Two pools and a stream were surveyed, *C. mathezii* was found in one of the pools and along the stream. The pool was almost dry, with only a small shallow pool remaining in the centre. *C. mathezii* was abundant forming sprawling mats (Fig.) on otherwise bare mud around a large, shallow, seasonally inundated depression surrounded by arable, as well as in the margins of a shallow stream arising c 200 m from the pool. Data were recorded on the species occurring within 50 cm of *C. mathezii* plants both in the pool and stream (Table 2.1).

Table 2.1 Quadrat data from the pool and stream at Oulmès

Quadrat No.	Oulmès pool						Oulmès stream	
	1	2	3	4	5	6	7	8
<i>Callitriche mathezii</i>	10	7	5	5	5	3	15	13
<i>Ranunculus peltatus</i>	10	10	10	8	8	20	25	10
<i>Agrostis pourretii</i>	5	20	8	12	10	3	10	5
<i>Callitriche brutia</i> var. <i>naftolskyi</i>	9		10	12	15	15	10	12
<i>Pulicaria arabica</i>	5	50	60	10	20	5		15
<i>Lythrum borysthenticum</i>	1	1	1	1			10	15
<i>Elatine hydropiper</i>	23	50	15	2	5			
<i>Botrydium granulatum</i>	30		5	40	35	30		
<i>Glyceria spicata</i>				5	2	12	20	15
<i>Mentha pulegium</i>						1	5	5
<i>Pilularia minuta</i>							5	10
<i>Crypsis</i> sp	10							

NB: number represent percentage cover

2.2.4 Seasonal pools in rocky desertic habitats at high altitude.

C. mathezii was recorded in three large pools in the high-altitude plateau between Azrou and Timahdit, as well as in a small pool cut off from a lake by a dam at Aguelmam Afennourir. In the three large pools, *C. mathezii* occurred with only a few other species (Table 2.4). However, in the small pool it occurred within a very diverse assemblage at 100 % over the pool, throughout well-defined inundation zones around the margin (Table 2.5).

Table 2.4 Species recorded within 50 cm of *C. mathezii* plants in pools between Azrou and Timahdite

	Pool 1	Pool 2	Pool 3
	Quadrat 15	Quadrat 16	Quadrat 17
<i>Callitriche mathezii</i>	5	10	20
<i>Ranunculus peltatus</i>	25	40	5
<i>Ranunculus batrachoides</i>	15	10	45
<i>Eleocharis palustris</i>	5		

Table 2.5 Species recorded in the small pool at Aguelmam Afennourir

Species	% cover	Species	% cover
<i>Agrostis pourettii</i>	≤1	<i>Juncus heterophyllus</i> (R)	3-5
<i>Alisma lanceolatum</i>	1-3	<i>Juncus inflexus</i>	≤1
<i>Alopecurus coeruleus</i>	≤1	<i>Juncus pygmaeus</i>	≤1
<i>Apium repens</i>	1-3	<i>Juncus tenageia</i>	≤1
<i>Callitriche mathezii</i>	≤1	<i>Lythrum borysthenticum</i>	3-5
<i>Callitriche truncata</i> subsp. <i>truncata</i>	3-5	<i>Lythrum portula</i>	1-3

<i>Damasonium bourgaei</i>	1-3	<i>Mentha pulegium</i>	3-5
<i>Drepanocladus aduncus</i>	≤1	<i>Montia fontana</i> subsp. <i>amporitana</i>	1-3
<i>Elatine macrocarpa</i>	3-5	<i>Nostoc</i> sp.	1-3
<i>Eleocharis acicularis</i>	3-5	<i>Ranunculus batrachioides</i>	≤1
<i>Eleocharis palustris</i>	40	<i>Ranunculus peltatus</i>	5
<i>Glyceria spicata</i>	1-3	<i>Rorippa hyanica</i> (VU, R)	≤1
<i>Groenlandia densa</i>	15	<i>Trifolium glomeratum</i>	≤1
<i>Isolepis setacea</i>	1-3	<i>Trifolium subterraneum</i>	≤1
<i>Juncus articulatus</i>	≤1	<i>Zannichellia palustris</i>	1-3
<i>Juncus bufonius</i>	≤1		

3 CONCLUSIONS

The taxon treated as *C. mathezii* includes significant variation, which in other members of the genus could justify it being split into at least two taxa. This can only be resolved through further morphological and molecular research. *C. mathezii* is capable of persisting in a terrestrial form and appears to be able to undergo fertilisation under water.

C. mathezii occurs in a fairly wide range of seasonal wetland types, from pool and a stream on soil to cupular pools in quartzite and granite and shallow lakes on dry rocky plains. It appears not to occur in permanent wetlands and was absent from a number of apparently suitable seasonal wetlands within the area surveyed.

C. mathezii is endemic to a small area in central Morocco with a range extending from 1,000-2,000 m from the Central Plain to the Moyen Atlas.

C. mathezii appears to be fairly abundant within a limited area, however the vulnerability of many of the sites where it occurs, combined with the limited number of sites and extremely restricted range mean that it should still be classed as Endangered.

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APPENDIX: SITE DATA

In this section, information is presented in a standardised format, listing the site name, geographical coordinates, altitude and a text which describes the wetland(s) and gives an indication of its conservation condition. Sites are listed in the order that they were visited. In this section * indicates that a herbarium specimen has been collected (lodged at the Institute Scientifique de Rabat), + indicates that material has been preserved in silica gel at the Institute Scientifique de Rabat and letter in parentheses indicate the IUCN threat status (DD - Data Deficient, EN - Endangered, VU - Vulnerable) or the National Status (R - Rare, RR - Very Rare, fewer than five sites known; V - Vulnerable, declining) (Fennane and Ibn Tattou 1998).



28th April 2019

1. Mar de Tiflet

33° 52' 17" N, 006° 16' 14.0" W, 381 m altitude.

This site involves a single, discrete seasonal pool adjacent to a major road and much frequented by local people. It is heavily dominated by emergent vegetation around the margins but with extensive open water toward the centre. In places it has broad poached margins which support a wide range of plants. Adjacent habitats include sheep- and donkey-grazed pasture and arable. The pool appears to be highly eutrophic; water is extracted for irrigation and it is very disturbed throughout.

Algae	
<i>Chara globularis</i>	<i>Spirogyra</i> sp.
<i>Chara vulgaris</i>	
Vascular plants	
<i>Bolboschoenus maritimus</i>	<i>Lythrum borysthenicum</i>
<i>Callitriche brutia</i> var. <i>naftolskyi</i> *	<i>Lythrum hyssopifolia</i>
<i>Callitriche regis-jubae</i> * (DD, V)	<i>Lythrum junceum</i>
<i>Ceratophyllum demersum</i>	<i>Lythrum tribracteatum</i>
<i>Cynodon dactylon</i>	<i>Polypogon monspeliensis</i>
<i>Cyperus longus</i>	<i>Pulicaria arabica</i>
<i>Eleocharis palustris</i>	<i>Ranunculus peltatus</i>
<i>Eryngium atlanticum</i> (R)	<i>Schoenoplectus litoralis</i>
<i>Glyceria notata</i>	<i>Holoschoenus vulgaris</i>
<i>Isoetes velata</i>	<i>Trifolium michelianum</i>
<i>Juncus bufonius</i>	<i>Trifolium resupinatum</i>
<i>Juncus pygmaeus</i>	<i>Typha angustifolia</i>
<i>Lemna gibba</i>	<i>Zannichellia</i> sp.

2. Stream upstream of the dam

This site involves a number of deeply incised streams flowing through arable which combine to form one channel which is dammed to form a small reservoir, presumably to provide drinking water and water for irrigation. The channels are generally sparsely vegetated due to shade from the steep banks on both sides but in places, particularly where the stream flows over rock exposures and where seepages emerge into the channel, there is more marginal vegetation, including a reasonable range of bryophytes. In general, the channel is in poor condition due to modification

of the bank for agriculture, probably combined with input of fertiliser and pesticides. However, where seepages arise, the vegetation is diverse and some appears to be in good condition.

Bryophytes	
<i>Aneura pinguis</i> <i>Bryum alpinum</i> <i>Lunularia cruciata</i>	<i>Philonotis</i> sp. <i>Riccia</i> sp
Vascular plants	
<i>Apium nodiflorum</i> <i>Callitriche brutia</i> var. <i>naftolskyi</i> <i>Callitriche stagnalis</i> * <i>Glyceria notata</i> <i>Isoetes velata</i> <i>Isolepis setacea</i> <i>Juncus bufonius</i> <i>Juncus capitatus</i> <i>Juncus heterophyllous</i> <i>Juncus pygmaeus</i> <i>Juncus tenageia</i>	<i>Linum bienne</i> <i>Lolium rigidum</i> <i>Lotus hispidus</i> <i>Lythrum junceum</i> <i>Lythrum portula</i> <i>Montia fontana</i> subsp. <i>amporitana</i> <i>Plantago coronopus</i> <i>Poa bulbosa</i> <i>Rumex acetosella</i> <i>Scrophularia auriculata</i>

28th-29th April 2019

3. Seasonal pools near Oulmès

This site involves a series of small to medium-sized seasonal pools in an area of mixed arable and unintensified pasture, with a shallow v-shaped valley containing a stream. Satellite images suggest that this area may include as many as five pools, only two pools were surveyed, together with a tributary of the stream which is probably seasonal in its upper reaches. The area is owned by an ex-minister, local government officials were contacted during our visit. It is generally in good condition, supporting a number of notable species.

3a. Larger pool

33° 25' 20.7" N, 005° 58' 35.2" W, 1170 m alt.



This site is a hollow approximately 40 m x 30 m, surrounded by arable but with a broad grazed, pastured zone around it probably involving the maximum extent of seasonal inundation. It is probably directly hydrologically linked to the stream (site 3c). At the time of the survey, the pool was largely dry with only a small area of standing water in the centre. Within the pool, vegetation occurred in three distinct zones:

- A central zone heavily dominated by *Elatine hydropiper*, with sparse *Callitriche mathezii*, growing as scattered shoots with a few flowers and a few other species such as *Pulicaria arabica*.
- A second zone with abundant *Botrydium granulatum*, *Callitriche brutia* var. *naftolskyi*, *C. mathezii*, *Glyceria spicata*, *Pulicaria arabica*, *Eleocharis palustris* and *Ranunculus peltatus*.
- A third, outer zone, more heavily vegetated, with species such as *Glyceria spicata*, *Mentha pulegium* and *Phalaris caerulea*.

In spite of the surrounding arable, this pool was in good condition with very diverse vegetation and good structure. It is vulnerable to agricultural intensification.

Algae	
<i>Botrydium granulatum</i>	
Vascular plants	
<i>Agrostis pouretii</i>	<i>Lotus hispidus</i>
<i>Anthoxanthum odoratum</i>	<i>Lythrum borysthenticum</i>
<i>Callitriche mathezii</i> * (EN, RR)	<i>Marsilea strigosa</i> (VU)
<i>Callitriche brutia</i> var. <i>naftolskyi</i> *	<i>Medicago polymorpha</i>
<i>Carum verticillatum</i>	<i>Mentha pulegium</i>
<i>Cerastium glomeratum</i>	<i>Myosotis sicula</i>
<i>Crypsis</i> sp	<i>Parentucellia viscosa</i>
<i>Echium plantagineum</i>	<i>Phalaris caerulea</i>
<i>Elatine hydropiper</i>	<i>Pulicaria arabica</i>
<i>Eleocharis palustris</i>	<i>Ranunculus chaerophyllos</i>
<i>Glyceria spicata</i>	<i>Ranunculus ophioglossifolius</i>
<i>Hordeum murinum</i>	<i>Ranunculus peltatus</i>
<i>Hypericum tomentosum</i>	<i>Sherardia arvensis</i>
<i>Isolepis setacea</i>	<i>Stachys arvensis</i>
<i>Juncus bufonius</i>	<i>Thapsia garganica</i>
<i>Juncus pygmaeus</i>	<i>Trifolium cherleri</i>
<i>Juncus tenageia</i>	<i>Trifolium michelianum</i>
<i>Kickxia spuria</i>	<i>Trifolium resupinatum</i>
<i>Linum bienne</i>	<i>Trifolium scabrum</i>
<i>Lotus conimbricensis</i>	

3b. Stream

This stream arises in a hollow in a gentle slope up from the valley base, with shallow water over deep, fine clay. It is heavily vegetated throughout much of its length, with vegetation grading from more strictly wetland-dependent species such as *Callitriche mathezii* and *Lythrum portula*, through a marginal fringe with species such as *Pilularia minuta* and *Ranunculus ophioglossifolius*, to species more typical of wet pasture.

Vascular plants	
<i>Agrostis pouretii</i>	<i>Lotus hispidus</i>
<i>Alopecurus pratensis</i>	<i>Lythrum borysthenticum</i>
<i>Anthoxanthum odoratum</i>	<i>Lythrum junceum</i>
<i>Callitriche brutia</i> var. <i>naftolskyi</i>	<i>Mentha pulegium</i>
<i>Callitriche mathezii</i> (EN, RR)	<i>Nasturtium africanum</i>
<i>Callitriche stagnalis</i>	<i>Nasturtium officinale</i>
<i>Carex divisa</i>	<i>Parentucellia viscosa</i>
<i>Carum verticillatum</i>	<i>Pilularia minuta</i> (VU, RR)
<i>Cladanthus mixtus</i>	<i>Pulicaria arabica</i>
<i>Echium plantagineum</i>	<i>Ranunculus chaerophyllus</i>
<i>Eleocharis palustris</i>	<i>Ranunculus ophioglossifolius</i>
<i>Glyceria spicata</i>	<i>Ranunculus peltatus</i>
<i>Hordeum murinum</i>	<i>Scrophularia auriculata</i>

Juncus bufonius
Juncus tenageia
Linum bienne

Stachys arvensis
Trifolium resupinatum
Trifolium subterranean



3c. Small pool in arable

33° 25' 25.3" N, 005° 58' 57.7" W, 1169 m alt.



This is a small pool very closely surrounded by arable but quite deep, such that it was mainly dominated by open water at the time of the survey. In spite of the proximity of the agriculture, this pool appeared to be in reasonable condition but it is very vulnerable to agricultural intensification.

Vascular plants	
<i>Agrostis poureii</i>	<i>Lythrum borysthenticum</i>
<i>Callitriche brutia</i> var. <i>naftolskyi</i>	<i>Lythrum hyssopifolia</i>
<i>Eleocharis palustris</i>	<i>Marsilea strigosa</i> (VU)
<i>Glyceria spicata</i>	<i>Mentha pulegium</i>
<i>Isoetes velata</i>	<i>Panicum repens</i>
<i>Juncus bufonius</i>	<i>Phalaris coerulescens</i>
<i>Juncus pygmaeus</i>	<i>Pulicaria arabica</i>
<i>Juncus tenageia</i>	<i>Ranunculus peltatus</i>

29th April 2019

4. Stream near Hotel des Thermes

A small stream, 1-2 m wide, much shaded by *Nerium oleander* and some other bushes, generally flowing through a fairly deep channel with gravel bars, but occasionally broken up by extensive rock outcrops where it forms a complex of pools. Adjacent habitats include a small-holding but are otherwise dominated by sheep-grazed pasture with scattered arable fields. The stream and its margins are generally in good condition.

Vascular plants	
<i>Apium nodiflorum</i>	<i>Mentha pulegium</i>
<i>Callitriche stagnalis</i>	<i>Montia fontana</i> subsp. <i>amporitana</i>
<i>Fontinalis</i> sp.	<i>Polypogon monspeliensis</i>
<i>Glyceria spicata</i>	<i>Pulicaria arabica</i>
<i>Lythrum junceum</i>	<i>Ranunculus peltatus</i>



5. Pools in granite outcrops near the Hotel des Thermes

A small number of shallow cupular pools on outcrops along a ridge above the valley of the river (site no. 4); none holding water at the time of the survey. One of the pools supported a *Callitriche* without mature fruit, but possibly *C. mathezii*. All of the pools are in outcrops surrounded by sheep-grazed pasture. The pools were generally in good condition, although there was some evidence of damage by stock.

Vascular plants	
<i>Callitriche</i> sp. <i>Crassula vaillantii</i>	<i>Isoetes velata</i>

6. Flushes on hill slopes near the Hotel des Thermes

Occasional flushes generally lying along the tops of exposed granite boulders in the hillside above the river, some were reasonably species-rich but most were fairly species-poor, probably as a result of over-gazing. All of the flushes are set in areas of sheep-grazed pasture.



Vascular plants	
<i>Cicendia filiformis</i> <i>Exaculum pusillum</i> <i>Isolepis setacea</i> <i>Juncus bufonius</i>	<i>Juncus pygmaeus</i> <i>Lotus hispidus</i> <i>Radiola linioides</i> <i>Solenopsis laurentia</i>

30th April 2019

7. River near Oulmès

A large probably permanent stream, flowing down from the village of Oulmès, to the west. The stream has reasonably diverse and extensive marginal vegetation, including poached areas, as well as localised inflow from springs and seepages. However, it appears to be very eutrophic, probably receiving various outflows from the village. The adjacent land is dominated by heavily sheep-grazed pasture with frequent trees, many of which appear to have been planted. Throughout much of its length, there is a heavy growth of diatoms and extensive filamentous algae, while the emergent vegetation is dominated by nitrophilous plant species.

Vascular plants	
<i>Apium nodiflorum</i> <i>Callitriche obtusangula</i> (V) <i>Callitriche stagnalis</i> <i>Carex divisa</i> <i>Ceratophyllum demersum</i>	<i>Lythrum hyssopifolia</i> <i>Lythrum junceum</i> <i>Lythrum portula</i> <i>Mentha pulegium</i> <i>Mentha suaveolens</i>

<i>Cyperus longus</i> <i>Glyceria spicata</i> <i>Hypericum tomentosum</i> <i>Isolepis setacea</i> <i>Juncus bufonius</i> <i>Lemna gibba</i> <i>Lotus hispidus</i>	<i>Montia fontana</i> subsp. <i>amporitana</i> <i>Nasturtium officinalis</i> <i>Polypogon monspeliensis</i> <i>Potamogeton nodosus</i> <i>Rumex pulcher</i> <i>Scrophularia aquatica</i> <i>Veronica catenata</i>
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8. Sidi Mrahe stream



33° 20' 02.3" N, 006° 01' 25.6" W, 1043 m alt.

This is a seasonal stream (oued) flowing through a fairly deep v-shaped valley over rocky substrate with patches of silt. At the time of survey, much of the stream was dry with occasional pools of water remaining, particularly in areas shaded by trees and shrubs. Adjacent habitats involved sheep-grazed pasture with abundant scrub and occasional small arable fields. The stream appears to be in fairly good condition, although there is some evidence of damage due to over-grazing and possibly excessive stock-watering.

Vascular plants	
<i>Anthoxanthum odoratum</i> <i>Callitriche stagnalis</i> <i>Cerastium glomeratum</i> <i>Juncus bufonius</i> <i>Nerium oleander</i> <i>Lemna gibba</i> <i>Nasturtium officinale</i>	<i>Plantago coronopus</i> <i>Ranunculus peltatus</i> <i>Scrophularia auriculata</i> <i>Stachys arvensis</i> <i>Veronica catenata</i> <i>Vitex agnus-castus</i>

9. Wetland complex at Mante

33° 14' 13.9" N, 005° 56' 59.3" W, 1163 m alt.

This site involves a linear series of small, seasonal pools along a seasonal stream (oued or wadi), set in an area of ungrazed rough-grassland between the road and a large expanse of intensive agriculture. Most of the different pools still held water at the time of the survey, although a few were dry and others showed extensive draw-down zones. The pools and stream generally appeared to be in good condition.

Vascular plants	
<i>Alopecurus pratensis</i> <i>Callitriche brutia</i> var. <i>naftolskyi</i> <i>Callitriche regis-jubae</i> (DD, V)	<i>Lythrum portula</i> <i>Mentha pulegium</i> <i>Montia fontana</i> subsp. <i>amporitana</i>

<i>Carex divisa</i>	<i>Nasturtium officinale</i>
<i>Carum verticillatum</i>	<i>Ornithogalum umbellatum</i>
<i>Eleocharis palustris</i>	<i>Phalaris caerulescens</i>
<i>Glyceria spicata</i>	<i>Pulicaria arabica</i>
<i>Isoetes velata</i>	<i>Ranunculus chaerophyllus</i>
<i>Juncus bufonius</i>	<i>Ranunculus peltatus</i>
<i>Juncus heterophyllus</i> (R)	<i>Rumex pulcher</i>
<i>Juncus tenageia</i>	<i>Sherardia arvensis</i>
<i>Leontodon saxatilis</i>	<i>Trifolium resupinatum</i>



10. Cupular pools in granite near Mante

33° 13' 26.6" N, 005° 56' 20.7" W, 1163 m altitude.

The area surveyed included five granite outcrops of different sizes, as well as a stream and very small seasonal pools in sheep-grazed pasture. Overall, only six pools were found and these typically supported only a few plants, one supporting *C. mathezii*. All of the pools appeared to be in reasonably good condition.

Vascular plants	Cupular pools						Stream	Seasonal hollows in field
	1	2	3	4	5	6		
<i>Callitriche mathezii</i> (EN, RR)	√	√						
<i>Callitriche regis-jubae</i> (DD, V)								√
<i>Callitriche stagnalis</i>							√	
<i>Crassula vaillantii</i>		√	√	√	√	√		
<i>Eleocharis palustris</i>								√
<i>Isoetes velata</i>		√	√	√				
<i>Juncus bufonius</i>				√				√
<i>Mentha pulegium</i>								√
<i>Montia fontana</i> subsp. <i>amportitana</i>							√	√
<i>Plantago coronopus</i>						√		
<i>Poa infirma</i>		√				√		
<i>Pulicaria arabica</i>		√		√				√

<i>Ranunculus ophioglossifolius</i>								√
<i>Ranunculus peltatus</i>							√	
<i>Sedum rubens</i>				√				
<i>Spergularia rubra</i>				√				



11. Mar de Arbassine

33° 10' 53.6" N, 005° 52' 51.3" W, 1066 m altitude.

This is a single, large pool adjacent to a school and surrounded by rocky outcrops, possibly a former quarry. Between some of the outcrops there are small pools which are joined to the main pool during high water but become isolated as water levels drop. Apart from these smaller pools, the margins are fairly narrow due to the steep adjacent rock outcrops. Adjacent habitats include dry, sheep- and goat-grazed hillslopes, scrub, a line of dense vegetation along the valley bottom and some agriculture. The pool appears to be quite eutrophic, probably due to its use for stock watering, resulting in high levels of poaching and dunging in the water and margins.

Algae	
<i>Chara globularis</i> Filamentous green algae	
Vascular plants	
<i>Bromus rubens</i> <i>Callitriche regis-jubae</i> (DD, V) <i>Crassula vaillantii</i> <i>Cynodon dactylon</i> <i>Cyperus longus</i> <i>Elatine macropoda</i> (RR) <i>Exaculum pusillum</i> <i>Juncus bufonius</i>	<i>Juncus pygmaeus</i> <i>Lotus hispidus</i> <i>Lythrum borysthenticum</i> <i>Mentha pulegium</i> <i>Pulicaria arabica</i> <i>Ranunculus peltatus</i> <i>Rumex bucephalophorus</i> <i>Trifolium campestre</i>



12. Stream Tna Ounahal

33° 12' 20.3" N, 005° 47' 31.6" W, 1129 m altitude.



This is a seasonally dry stream (oued or wadi) flowing through a very rocky landscape, dominated by oak woodland on the higher ground, with sheep-grazed pasture and some arable fields on level ground on the bottom of the valley.

The stream flows among rock outcrops and stony ground and consequently has only a very narrow margin, but the vegetation is reasonably diverse. At the time of the survey, water levels were low and the stream was beginning to break up into pools. The stream appeared to be in good conservation condition.

Vascular plants	
<i>Callitriche regis-jubae</i> (DD, V)	<i>Mentha pulegium</i>
<i>Callitriche stagnalis</i>	<i>Montia fontana</i> subsp. <i>amporitana</i>
<i>Crassula tillaea</i>	<i>Poa annua</i>
<i>Crassula vaillantii</i>	<i>Polycarpon tetraphyllum</i>
<i>Cyperus longus</i>	<i>Sagina apetala</i>
<i>Juncus bufonius</i>	<i>Sedum rubens</i>
<i>Lotus conimbricatus</i>	<i>Spergularia rubra</i>

1st May 2019

13. Akzou

coordinates	altitude	coordinates	altitude
33° 07' 10.4" N, 005° 54' 06.3" W	1487 m	33° 07' 15.9" N, 005° 53' 49.5" W	1451 m.
33° 07' 10.27" N, 005° 54' 7.55" W	1433 m	33° 07' 19.3" N, 005° 53' 44.0" W	1433 m.
33° 07' 11.1" N, 005° 54' 06.3" W	1486 m	33° 07' 25.3" N, 005° 53' 33.5" W	1433 m
33° 07' 14.6" N, 005° 53' 43.8" W	1433 m		



This site involves a series of cupular pools in rock outcrops around the type locality for *C. mathezii*. Two rock pool complexes were surveyed, the lower one involving broken, rather steeply bedded rocks with a few pools, the upper one on the col with flat rocks is the type locality for *C. mathezii* which occurred in both areas. Coordinates were taken for widely separated pools. Surrounding habitats were almost exclusively dominated by *Quercus ilex* and *Q. suber* woodland. The pools and associated habitats appeared to be in very good condition, in spite of some grazing by sheep and goats, as well as unofficial harvesting of cork.

Algae	1	2	3	4	5	6	7
Filamentous green algae				√			

Vascular plants							
<i>Callitriche brutia</i> var. <i>naftolskyi</i>	√						
<i>Callitriche mathezii</i> (EN, RR)	√		√	√			
<i>Crassula vaillantii</i>	√	√	√	√	√	√	√
<i>Isoetes velata</i>	√						
<i>Lythrum thymifolium</i>	√	√	√		√		
<i>Plantago coronopus</i>					√		√
<i>Spergularia rubra</i>	√						√



15. Cupular pools on an outcrop near Akzou

33° 09' 48.8" N, 005° 53' 34.2" W, 1171 m altitude.

This site involved a low, domed rock outcrop, at lower altitude and to the north of the previous site (No. 14) but with similar pools. The area is heavily grazed by sheep and goats, but the pools (which were mainly dry) appeared to be in good condition.

Vascular plants	1	2	3	4	5	6	7
<i>Callitriche brutia</i> var. <i>naftolskyi</i>					√		
<i>Crassula vaillantii</i>	√	√	√	√	√	√	√
<i>Isoetes velata</i>					√		
<i>Juncus bufonius</i>					√		
<i>Lotus hispidus</i>					√		
<i>Lythrum portula</i>					√		
<i>Plantago coronopus</i>			√	√	√	√	
<i>Poa infirma</i>					√		
<i>Spergularia rubra</i>				√	√	√	

2nd May 2019

14. Seasonal lakes between Azrou and Timahdite (Jbel Hebri)

33° 20' 41.7" N, 005° 01' 16.1" W, 1928 m altitude

This site involves a large, very shallow seasonal lake in a stony, high altitude desertic landscape dominated by sheep-grazed pasture. The lake itself was largely bare and appeared over-grazed.

Vascular plants	
<i>Callitriche mathezii</i> (EN, RR)	<i>Ranunculus batrachoides</i>
<i>Eleocharis palustris</i>	<i>Ranunculus peltatus</i>



33° 17' 21.8" N, 005° 10' 50.2" W, 1928 m altitude

This site is a large, seasonally dry lake, approximately 200 x 300 m but not more than 1 m deep, supporting dense vegetation dominated by *Ranunculus peltatus*. It is surrounded on all sides by a stony, high altitude desertic landscape dominated by sheep-grazed pasture. At the time of the survey there was a fairly narrow drawdown zone, within which *C. mathezii* was forming extreme terrestrial forms. The lake appeared largely to be in good condition.

Algae	
<i>Nitella cf. opaca</i>	
Vascular plants	
<i>Callitriche mathezii</i> (EN, RR)	<i>Ranunculus batrachoides</i>
<i>Callitriche truncata</i> subsp. <i>truncata</i> (DD, R?)	<i>Ranunculus peltatus</i>
<i>Eleocharis palustris</i>	



33° 18' 45.3" N, 005° 03' 56.1" W, 1912 m altitude

This is another seasonally dry lake, supporting dense vegetation dominated by *Ranunculus peltatus*. It is surrounded on all sides by a stony, high altitude desertic landscape dominated by sheep-grazed pasture. *C. mathezii* was abundant throughout the lake. In spite of fairly heavy grazing, the lake appeared to be in good condition.

Vascular plants	
<i>Callitriche mathezii</i> (EN, RR)	<i>Ranunculus batrachoides</i>
<i>Crassula tillaea</i>	<i>Ranunculus peltatus</i>
<i>Elatine macropoda</i> (RR)	
<i>Eleocharis palustris</i>	



3rd May 2019

15. Seasonal pools near Azrou

33° 29' 50.8" N, 005° 16' 35.0" W, 1432 m altitude



This site involved two seasonally wet hollows, one on each side of the N13 north of Azrou. Both of the hollows had dried out completely shortly before the survey but supported a rich variety of wetland-dependent plants. They are surrounded by arable, with some planted coniferous woodland. Some similar hollows in the complex have been damaged by building and these two hollows are extremely vulnerable; however, they remain in good condition.

Bryophytes	
<i>Bryum alpinum</i>	
Vascular plants	
<i>Cerastium glomeratum</i>	<i>Marsilea strigosa</i> (VU)
<i>Crassula tillaea</i>	<i>Myosurus minimus</i> (RR)
<i>Crassula vaillantii</i>	<i>Plantago coronopus</i>
<i>Damasonium polyspermum</i> (VU)	<i>Poa annua</i>
<i>Elatine macropoda</i> (RR)	<i>Polypogon monspeliensis</i>
<i>Eleocharis palustris</i>	<i>Ranunculus batrachoides</i>
<i>Isoetes velata</i>	<i>Ranunculus chaerophyllus</i>
<i>Lepidium violaceum</i> (VU)	<i>Ranunculus peltatus</i>
<i>Lotus hispidus</i>	<i>Spergularia rubra</i>
<i>Lythrum thymifolia</i> (R)	<i>Trifolium resupinatum</i>
<i>Polygonum aviculare</i>	<i>Trifolium subterraneum</i>

10th June 2019

16. Aguelmam Afennourir

33° 17' 07.7" N, 5° 15' 07.7" W, 1801 m altitude.



The site was surveyed as part of the work to validate the Sebou catchment KBA. It involves a small, seasonally inundated pool in pasture, cut off from the lake Aguelmam Afennourir by a dam carrying a small road. The pool is heavily vegetated and very species-rich, including four threatened species. Parts of the lake appear to be somewhat over-grazed and lack emergent vegetation, but this subsidiary pool supports structurally diverse and species-rich vegetation and is in good conservation condition.

Algae	
<i>Nostoc</i> sp.	
Vascular plants	
<i>Agrostis pourettii</i> <i>Alisma lanceolatum</i> <i>Apium repens</i> (VU) <i>Callitriche mathezii</i> (EN, RR) <i>Callitriche truncata</i> subsp. <i>truncata</i> (VU, R?) <i>Damasonium bourgaei</i> <i>Drepanocladus aduncus</i> <i>Elatine macrocarpa</i> (RR) <i>Eleocharis acicularis</i> <i>Eleocharis palustris</i> <i>Glyceria spicata</i> <i>Groenlandia densa</i> <i>Isolepis setacea</i> <i>Juncus articulatus</i> <i>Juncus bufonius</i> <i>Juncus heterophyllus</i> (R)	<i>Juncus inflexus</i> <i>Juncus pygmaeus</i> <i>Juncus tenageia</i> <i>Lythrum borysthenicum</i> <i>Lythrum portula</i> <i>Mentha pulegium</i> <i>Montia fontana</i> subsp. <i>amporitana</i> <i>Nostoc</i> sp. <i>Phalaris coerulescens</i> <i>Ranunculus batrachioides</i> <i>Ranunculus peltatus</i> <i>Rorippa hyanica</i> (VU, R) <i>Trifolium glomeratum</i> <i>Trifolium subterraneum</i> <i>Zannichellia palustris</i>