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The cost of the Mediterranean collections

Abstract

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The roots of plant taxonomy are very much connected with the Mediterranean. As a result, this area of c. 2.090.000 km^2 houses 229 herbaria registered in Index Herbariorum and a total of c. 27.000.000 specimens involving 21 countries. The size of the collections varies substantially but the majority fall under the "magic" number of 74.000 specimens, the number suggested to be adequately curated by 1 full-time staff. Some of these small Mediterranean herbaria house material of particular Mediterranean collector(s) and are historical in nature; at the other end of the spectrum, other herbaria have expanded their scope, even to faraway ex-colonies, and are very active.
A project on the historical collection of Moritz Willkomm "*Herbarium mediterraneum pyrenaicum et canariense*" housed at COI, involving databasing, imaging, restoration and typification, was the stimulus for the exercise of extrapolating from this study case to the vast collections in the Mediterranean in financial terms and time-scales. Calculations are on the basis of 4.082 € per specimen and 10.96 specimens dealt with by 1 person per day. The exercise is meant to be thought provoking. Some data refer to Turkey in particular.

Introduction

Herbaria are biological collections, physical databases of plant variability. They are of fundamental importance in research and naming plants accurately; a fact which is not always generally recognised. Herbarium specimens document the incredible diversity of plants and are the foundation of our knowledge of it – their labels, if adequate, document the identity, habitat, phenology and distribution of species. Only with large quantities of material and with a wide age span it is possible to make comparisons and draw scientific conclusions on taxa, habitats and whole ecosystems. Material collected and investigated long ago can reveal new insights when re-examined in the light of new techniques, such as variable pressure scanning electronic microscopy and molecular investigation.

It is very appropriate in this International Year of Biodiversity (2010) to emphasise the essential need to accelerate the study of plant diversity. Fast communication and information exchange has never been made so easy with the present-day electronic facilities that both store enormous amounts of information and provide easy access to information in the internet. Biodiversity informatics facilitates the efforts to resolve the intrinsic slowness of the study of biodiversity because of the enormous number of living organisms (estimated at c. 14 million; Hawksworth & Kalin-Arroyo 1995) and the fact

that, at least in the case of plants, they are deposited in too many scattered collections, frequently not adequately maintained.

Projections on biodiversity composition point to continuation or acceleration of depletion (Sala & al. 2005). In this scenario, the specialists, the taxonomists, are called on to produce biological information and decisions at faster rates. It takes a long time to train taxonomists – their job is multi-disciplinary and covers many organisms. Sadly, however, a combination of factors is currently heading taxonomists towards extinction in many parts of the world. This problem was recognized as an impediment ("taxonomic impediment") to conservation and the sustainable use of biodiversity by "The Darwin Declaration" (Environment Australia 1998).

The Mediterranean Region is an area of c. 2 million km^2 and has c. 22.000 species of vascular plants of quite high ecosystem service value (Mittermeier & al. 2004; Turner & al. 2007). The many herbaria in the region are a testimony to past and present botanical endeavours in the area. However, many of these collections are small, sometimes the result of the work of a single man, and often historical in nature; other collections are the property of universities where taxonomy, again sadly, has become a minor subject or absent in the curricula, ignoring the fact that scientifically accurate classifications are at the core of any research in biology; other herbaria, although housing large and precious collections are today under-staffed. But a few are active and working at their best. Although the present situation is not simple to resolve, technology makes possible strategic changes that can place Mediterranean herbaria and taxonomy in a better position as far as the study of biodiversity is concerned.

The *Herbarium mediterraneum pyrenaicum et canariense* of Moritz Willkomm is a historical collection of 31.292 specimens, housed separately at the Herbarium of the Department of Life Sciences of the University of Coimbra (COI). It is a good example of many of the collections in the Mediterranean, both in size and state of conservation (i.e. not ideal). The experience acquired during the on-going Willkomm Herbarium project prompted me to examine the Mediterranean collections as a whole and make a very rough estimate of the time and costs for a revamp of the herbaria throughout the Mediterranean.

Herbarium of Willkomm at COI

Moritz Heinrich Willkomm (1821-1895) sold his private *Herbarium mediterraneum pyrenaicum et canariense* to Júlio Henriques, the founder of COI. In the library of the Department of Life Sciences in Coimbra, there is regular correspondence between Henriques and Willkomm from 1877-1895, mostly in French, including the letters on the transaction of the herbarium (Fernandes 1977). Willkomm never explained the reason for the sale. However, five years had passed since his third and last trip to the Iberian peninsula (1873) and the seminal work based on the herbarium, the *Prodromus flora hispanicae* of Willkomm & Lange (1861-80), was well under way. Because Willkomm had been working at Prague as professor of Botany and director of the Botanic Garden for four years, he probably considered his work on the flora of the Iberian peninsula to have come to a close. On the 18th October 1878, Willkomm wrote to Henriques explaining in detail his conditions for the sale of his herbarium, which "... *contenant à présent 10.000 espèces*

en 100.000 échantillons au moins (il será augmenté encôre par des collections considérables de plantes de la Corse et de l'Espagne, que je recevrai bientôt)...". The concern of Willkomm on keeping the herbarium intact was also obvious in this letter. This condition was included in the contract of the 22nd of December 1878 and the collection has remained separate ever since (COI-WILLK). The price was set at 7.000 francs to be paid with a first instalment of 2.000 francs, followed by five annual instalments of 1.000 francs each. In spite of some frustrating bureaucracy in both countries, the last delivery was on the 18th May 1880, exactly 130 years ago, and all the payments were duly made. In truth, this was the starting core of today's Herbarium at COI.

The herbarium is still in its original 176 numbered bundles and includes algae, fungi, lichens, bryophytes, pteridophytes, gymnosperms and angiosperms. The specimens are from the above referred areas but also from other regions, certainly included there by Willkomm for comparison, these including France, the Alps, the Balkans, Poland, Russia, Ukraine, Kazakhstan, Uzbekistan, Mongolia, even China and also very few from the Arabian peninsula. The sequence of the families is that of the *Prodromus* but there is material outwith the area of the Flora. The species covers have the species names handwritten by Willkomm himself, being those the names in the *Prodromus*. The specimens (no individual covers) do not always bear the same name as the outside cover, the understanding being that the final determination of Willkomm is the one on the species cover. The species in the same genus are in a cover of a different colour, also labelled by Willkomm. So far, 510 collectors have been identified but it is impossible to list them all because Willkomm himself indicated "?" for some. There are 50 Spanish collectors, 6 Portuguese, but most are French and German (Silva 2002).

The present-day importance of the collection compares with some others throughout the Mediterranean: (1) based on it was written the Flora of a specific area, in this case, the first Flora of virtually the whole of the Iberian Peninsula (*Prodromus florae Hispanicae* (*l.c.*); (2) the number of type specimens is reasonably high; and (3) brings together a wide spectrum of historical collectors, their handwriting and the means to clarify their *modus operandi*. For those who work on nomenclatural issues and particular Floras (in this case the on-going *Flora iberica*), access to this kind of collection is a must. However, very often these specimens are old and in a delicate state of conservation, therefore loans are not possible, even consultation *in loco* is done under supervision. A 3-year project at Coimbra, "Willkomm Herbarium: historical collection online", aims to provide better access to the information contained in it. The Herbarium is being: (1) databased, SPECIFY (Kansas University©) is the free software used, the information being made available in the site of COI (http://www.uc.pt/herbario_digital); (2) digitised (except algae, fungi, lichens and bryophytes), the images being organised in folders exactly as in the actual herbarium, creating a virtual collection; (3) the Poaceae fully restored as a trial run; and (4) the Brassicaceae typified. The final result will make possible consultation of the virtual Herbarium for most purposes without handling the specimens in their fragile state. The time and money (2009) allocated to the project are on Table 1. The cost of 1 specimen databasing, imaging, going through basic restoration and placing its information on-line is estimated at 4.082 €; 10.96 specimens are altogether dealt with by 1 person per day; databasing and imaging only are 3.180 €.

Table 1. Basic description of the on-going 3-year project "Willkomm Herbarium: historical collection online" at the Coimbra Herbarium (COI). Time and budget were used to estimate costs to revamp the herbaria throughout the Mediterranean (Tables 4 and 5); also to estimate the cost of databasing, imaging, going through basic restoration and placing the information online of 1 specimen (4.082 €).

TASKS	MATERIALS and METHODS	COST (€)	TIME (YEARS)
DATABASING	2 desktop computers; 2 barcode readers; barcode printer; thermal transfer ribbon+labels; 2 external disks; SPECIFY (JAVA)	3.220 € (Materials) 80.000 € (2 Personnel)	2,5
IMAGING	digital camera; copy stand; scales; copy stand; light sources; light tent; desktop computer; monitor calibrator; barcode reader; external disk; UPS	1.950 € (Materials) 11.450 € (1 Personnel)	1
RESTORING	museum quality paper+glue+pen; poly-ethylene transparent covers; humid silica gel; sealed box for humidifying specimens (+imaging equipment)	4.000 € (Materials) 24.000€ (Personnel)	1,5
ONLINE	http://www.uc.pt/herbario_digital/herbarioonline/herbario_online	2.000 €+ (Personnel)	¼
TOTAL	3 persons working on and off during 3 years to database, place information online, create a virtual herbarium and basically restore 31.000 specimens	126.570 €	7.75 (1 person)

Time and cost to revamp Mediterranean herbaria

Mediterranean herbaria *vs* plant collections of the Mediterranean is a decision that has to be made for any assessment. The Mediterranean is a unit from the phytogeographical viewpoint but it is also a unit in many other ways and throughout we share many logistic problems. For this reason, my focus in the present assessment is on herbaria in the Mediterranean, being aware that some also house collections outside the area. For the sake of argument I also included two herbaria (FT and LISC) that house exclusively African collections.

The time and cost of activating and modernising the plant collections in the Mediterranean are both very difficult to assess. Surprisingly, information seems to be in many cases out-dated, the reason often being the state of the decline itself of many herbaria. *Index Herbariorum* (http://sweetgum.nybg.org/ih/, accessed in March 2010) was the source of information, but at least for Portugal and Turkey, data on staff is frequently out-dated and numbers over-estimated. I was able to correct some staff numbers for Portugal, Turkey, and Spain, the latter based on information from the Asociación de Herbarios Ibero-Macaronésicos. For France, only herbaria in the Mediterranean south were selected (Bayonne and Bagnères-de-Bigorre, near to the Pyrenees, were included to make it comparable to Spain where all herbaria were included); whereas for Turkey all herbaria were included, so that the situation of the host country of this OPTIMA meeting would be clearer. For University herbaria, staff numbers refer to lecturers and researchers who often are only minimally involved in curation. The results are in Tables 2-5. These results are meant only as a starting point for a discussion to revamp the Mediterranean herbaria.

Table 2. Content assessment of the herbaria in the Mediterranean region. Data is mostly based on information from *Index Herbariorum* (http://sweetgum.nybg.org/hi, accessed in March 2010)how innacurate it may be. French herbaria selected are essentially those in the Mediterranean south; for Turkey all herbaria were included. *indicates the ideal number of specimens curated by 1 member of staff according to Parnell (2001); **for larger collections the herbarium and staff numbers are indicated.

COUNTRY	HERBARIA BY SPECIMEN NO.						TOTALS		
	<10.600 (1/7x1)	<74.000* (1)	<148.000 (2x1)	<740.000 (10x1)	<1.480.000** (20x1)	<4.000.000** (54x1)	Herbaria	Specimens	Staff (specimen/1 staff)
1. ALBANIA							?		
2. ALGERIA				1			1	350.000	?
3. BOSNIA-HERZEGOVINA			1				1	110.000	1 (110.000)
4. CROATIA	2	4	1	1			8	345.989	20 (17.300)
5. CYPRUS	2						2	10.200	5 (2.040)
6. EGYPT	4	3		2			9	679.800	70 (9.711)
7. FRANCE	2	8		5		1 (MPU/8)	16 (out of 57)	5.972.720	29 (205.955)
8. GREECE	2	3	2	1			8	518.050	42 (12.335)
9. ISRAEL	2	2		1			5	791.900	16 (49.494)
10. ITALY	14	31	9	10	2 (RO/8; TO/4)	1 (FI/10)	67	10.246.593	277 (36.948)
11. LEBANON		1					1	68.000	1 (68.000)
12. LIBYA		2					2	50.000	10 (5.000)
13. MALTA	1						1	10.000	1 (10.000)
14. MONTENEGRO	1		1	1			3	650.000	25 (26.000)
15. MOROCCO		1	1				2	190.000	7 (27.143)
16. PORTUGAL (except Atlantic Is.)	3	5	2	2	1 (COI/3)		13	1.737.000	54 (32.167)
17. SERBIA			1	2			3	720.000	26 (27.692)
17. SLOVENIA		1	1				2	200.000	3 (66.667)
18. SPAIN (except Canary Is.)	11	23	5	6	1 (MA/15)		46	3.983.892	322 (12.372)
19. TUNISIA	1						1	5.000	?
20. TURKEY	16	15	1	1			33	1.010.319	200 (3.527)
21. YUGOSLAVIA									
TOTAL	**61**	**99**	**25**	**33**	**4**	**2**	**224**	**27.649.463**	**1.109 (24.381)**

The total of 27 million specimens housed in the Mediterranean herbaria (Table 2) may be an over- estimate but it gives an idea of the size of the problem at hand. The countries with the most significant collections are, in decreasing order, Italy, France, Spain, Portugal and Turkey, with specimen numbers c. 1 million and above, followed by Israel, Serbia, Egypt and Montenegro. Of the countries holding larger collections, those with less staff on the whole apparently are France, Slovenia, Israel, Italy and Portugal; Spain is, by far, the best staffed country. It is interesting to note the distribution of herbaria according to size (Table 3), 71,4% having less than 74.000 specimens. These herbaria have 58.5% of the total staff dealing with only 13.2% of the total specimens. The disproportion between human resources and specimen number is even more critical at the other end of the scale where the largest herbaria (above 740.000) have 4.8% of the total staff to 41.5 % of the specimens.

Italy is well set aside in number of herbaria with 1/3 more than the nearest other country, Spain. However, the number of Italian herbaria in the first category (smaller than 10.600 specimens) and also the second (smaller than 74.000 specimens) compare with those of Spain and even Turkey. It can be argued that Italy has a better distribution of herbaria per category, up to the very large herbaria (FI), especially so when compared with Turkey where the largest herbarium has only 200.000 specimens. Small herbaria can be useful as regional collections in teaching, training and identification, especially in large countries. However, they can be particularly undesirable for taxonomy as small scattered institutes create a scenario for scattered and sometimes inaccessible type specimens. When well kept, they consume more resources than if they are merged into a larger institute. However, some lack most facilities and the 1 staff associated to them in *Index Herbariorum* (*l.c.*) is, in fact, a part-time job only. Some small herbaria would benefit from being merged. In the countries where they remain individually, firm policies should be implemented to guarantee the deposition of type specimens in a main or national herbarium. The Herbarium Mediterraneum in Palermo is an obvious place to centralise many Mediterranean types or their duplicates.

Table 3. Assessment of the herbaria in the Mediterranean region by comparing herbaria performance between size categories.

TOTALS	HERBARIA BY SPECIMEN NO.			
	<10.600	<74.000	74.000-740.000	740.000-1.480.000
HERBARIA NO. (%)	61 (27.2)	99 (44.2)	58 (25.9)	6 (2.7)
STAFF NO. (%)	225 (20.3)	424 (38.2)	412 (37.2)	48 (4.3)
SPECIMEN NO. (%)	410.619 (1.5)	3.223.344 (11.7)	12.535.500 (45.3)	11.480.000 (41.5)
SPECIMENS NO. PER 1 STAFF	1.825	7.602	30.426	239.167

Table 4. Assessment of the herbaria in the Mediterranean region by comparing costs (time and budget) to revamp the collections.

HERBARIA	HERBARIA BY SPECIMEN NO.				TOTALS	
	<10.600	<74.000*	74.000-740.000	740.000-1.480.000	Herbaria	Specimens
NO.	61	99	58	6	224	27.649.463
BUDGET (€)	1.676.147	13.157.690	51.169.911	46.861.360		112.865.108
TIME (YEARS)	0,46	1,9	7,6	60		6,23

The estimated cost of revamping all the herbaria within the Mediterranean and the time needed to do so is given on Table 4. The c. 113×10^6 € is an enormous sum and therefore, priorities should be established and an accurate assessment of the present state of the collections is important since some have already started the process of modernization. If the staff listed in *Index Herbariorum* would truly be curating staff who could be involved full-time on this, the job would take only 6.23 years (Table 4). But the problem is that most of the listed staff, especially at university herbaria, is only nominally curating staff – and the university herbaria represent the majority, 63.8%. The present difficulties of so many of the Mediterranean herbaria do not correspond to the generous numbers of specimens per staff within countries (Table 2) and herbaria category size (Table 3). In fact, the ideal 74.000 specimens curated by 1 staff member (Parnell, 2001) are only exceeded by France and Bosnia-Herzegovina and by the 6 very large herbaria in the area (<740.000 speci-

Table 5. Assessment of the Turkish herbaria by comparing costs (time and budget) to revamp the collections.

TURKEY	HERBARIA BY SPECIMEN NO.				TOTALS
	<10.600	<74.000*	<74.000	<740.000	
HERBARIA NO.	16	15	1	1	33
SPECIMEN NO.	105.946	626.373	78.000	200.000	1.010.319
STAFF NO.	64	101	6	11	
COST €	432.471	2.556.855	318.396	816.400	4.124.122
TIME (YEARS)	0.41	1.55	3.25	4.54	1.26

mens). The abyssal differences between the time for revamping the very large and the small herbaria with their own staff (60 *vs* 0.46 years) reveal the major difficulties the very large herbaria are going through.

The case of Turkey, the host country of this OPTIMA meeting, is given in greater detail in Table 5. The too high proportion of small Turkish herbaria indicates a recent activity in plant taxonomy. At such early stage of growth, strategic decisions are of major importance, especially when many herbaria are rather remote, as it is the case in Turkey. A national herbarium, where types and duplicates would have to be deposited would be a major asset to establish standards, give a strong lead on modernization, combine resources and efforts and would facilitate the future study of the large Turkish flora for all botanists.

Conclusions

Clearly, the present-day situation with the numerous herbaria in the Mediterranean area is far from healthy. In recent decades, the importance of biological collections of all kinds has neither been given the recognition, nor the funding that they merit and require. The Tables in this paper clearly illustrate the scale of the problem both in terms of money and staffing. The present "taxonomic impediment" throughout the Mediterranean herbaria constitutes an impediment to growth. It is, to a great extent, a waste of past expenses if main collections freeze in time and become merely historical. Opportunities are missed when there is no staff to follow up different projects. Shortage of competent staff also leads to waste of time. The Coimbra University Herbarium (COI) with c. 800.000 specimens has 1 part-time curator, 1 part-time researcher and 1 staff. Budget for modernization has come from research projects such as the one referred here, the Willkomm Herbarium. Time was consumed in training the present team; but for the next project there will be, very likely, a new team and, yet again, time consumed in training.

Turkey is now botanically one of the most active countries in the Mediterranean; it has c. 50 small to large herbaria throughout the country with type specimens housed in a fair number of them. But, there is no national herbarium and, equally relevant, no complementary national botanical library.

This paper has not addressed the details as to how the overall problems with Mediterranean collections can be resolved. But it can be used as a starting point that curators of herbaria, like myself, can use in future discussions. Maybe, some of these discussions could take place within OPTIMA.

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