Bayed A. & Ater M. (éditeurs). Du bassin versant vers la mer : Analyse multidisciplinaire pour une gestion durable.
Travaux de l'Institut Scientifique, Rabat, série générale, 2008, n°5, 17-26.

The Thermo-Mediterranean biotopes of the Oued Laou basin: a landscape approach

Louis F. CASSAR[1], Elisabeth S. CONRAD[2], Paul GATT[2], Edwin LANFRANCO[3] & Avertano ROLÉ[4]

[1] *University of Malta, International Environment Institute, Msida MSD 2080, Malta* – e-mail: louis.f.cassar@um.edu.mt
[2] *University of Malta, International Environment Institute, Msida MSD 2080, Malta*
[3] *University of Malta, Faculty of Science, Department of Biology, Msida MSD 2080, Malta*
[4] *University of Malta, Mediterranean Institute, Geography Division, Msida MSD 2080, Malta*

Abstract. The Oued Laou basin in northwest Morocco constitutes a range of geological, geomorphological, hydrological and microclimatic regions. As a result, the vegetation in the area can be divided into different zones, corresponding largely with altitude, within which a variety of floral patterns emerge. A number of research stations were identified across the Thermo-Mediterranean zone of the basin, with a view to assessing the different biotopes and floral assemblages present, based, in particular, on dominant, characterising and indicators species. Diptera were also sampled in order to establish whether the biotopes at the different research stations were colonised by stenotopic species. The results provide a baseline record of the situation at present. As expected, water flow through the oued was found to be a key factor in determining vegetation composition and extent. Indicators of disturbance, both natural and anthropogenic, were also identified. The findings could be incorporated into a future landscape baseline, which would have utility for monitoring purposes, particularly given ever-increasing pressures on the natural environment.

Key words: Oued Laou basin, thermo-Mediterranean biotopes, landscape ecology, Diptera biodiversity.

Les biotopes thermo-méditerranéens du bassin versant de Oued Laou : approche paysagère.

Résumé. Le bassin versant Oued Laou dans le nord-ouest du Maroc comprend toute une gamme de zones qui se définissent en fonction de leur géologie, géomorphologie, hydrologie et microclimat. En conséquence, la végétation dans la région peut être divisée en zones différentes, en correspondance, pour une grande part, avec l'altitude en fonction de laquelle une variété de modèles de flore est mise en évidence. Plusieurs stations d'étude ont été sélectionnées à travers la zone thermo-méditerranéenne du bassin versant, dans le but de caractériser les différents biotopes présents et évaluer les assemblages floristiques en se basant, en particulier, sur les espèces caractéristiques et indicatrices. Les Diptères ont également été échantillonnés pour savoir si les biotopes des différentes stations d'étude ont été colonisés par des espèces sténotopiques. Les résultats fournissent un état de référence de la situation. Comme attendu, la circulation de l'eau le long de l'oued s'avère être un facteur clé dans la composition et l'étendue de la végétation. Les indicateurs de perturbation, d'ordres naturel et anthropique, ont été également identifiés. Les conclusions pourraient être incorporées dans un futur état de référence pour les besoins de la recherche et particulièrement pour les données sur l'environnement naturel.

Mots clés : Bassin versant de Oued Laou, biotopes thermo-méditerranéens, écologie du paysage, biodiversité des diptères.

INTRODUCTION

The Oued Laou basin, located on the northwest segment of Morocco, within the provinces of Tétouan and Chefchaouen, constitutes a catchment of around 930 km^2 that extends from the mountainous region of the Rif in the central region of the Tétouan promontory to the Mediterranean coastal plain that bounds the eastern shores of the promontory to the sea.

The main land-use in the region is agriculture; with pastoral activity mostly occurring along the steeper landscape elements, while arable cultivation is restricted to the lower reaches of the drainage basin where large tracts of flat land are available. Other activity, essentially but not exclusively of an economic nature, also occurs within the basin but this is largely focused upon the rural sector. Notable exceptions, in this regard, include the hydro-electric power generating plant located appropriately on the river-course and a fast-growing tourist sector. This service industry largely caters for the domestic market at the coastal settlement of Oued Laou while accommodation in Chefchaouen caters for both the domestic and the international markets. From the point of view of demography, some 59% of the population is widely dispersed in rural areas throughout the basin, while the rest inhabit nascent urban centres. Population growth will no doubt generate some stress on the landscape with arable cultivation extending onto more marginal areas. Soil erosion from cultivation along some of the steeper slopes is markedly evident while cultivation along riparian terraces is always a high-risk activity.

With regard to landscape, the Oued Laou basin is exceedingly diverse, exhibiting significant contrast. For example, the region's relief consists of mountainous escarpments, alluvial plains and a variety of coastal landforms. Oued Laou's genetic floodplain shows a strong affinity to the river channel that formed it, with a morphology that reflects oued flow and catchment conditions. From observations carried out by the authors during different times of the year (latter part of April/early May, end June and early December) it appears that the Oued Laou river channel transforms itself from a high-energy environment to a low-energy one, depending on levels of precipitation and water run-off intensity within the

region's watershed. Human activity also exerts a considerable influence on valley morphology. Braided flow is evident within the lower elevations and this indicates a seasonal flow regime, which possesses an abundant supply of sediment. Much of this sediment is probably derived from agricultural activity, which is identified by considerable gullying, sheetwash, and associated mass movement. However, whether or not sediment dynamics alter from a non-cohesive to a cohesive nature and vice-versa, as flow rates fluctuate temporally, cannot be discerned without adequate dedicated studies on the area's sedimentology.

The thermo-Mediterranean zone, which comprises land-cover between 0 and 900 m above sea level, is fairly widespread within the lower reaches of the basin. In view of the fact that it features different bio-climatic regimes, ranging from hyper-arid and semi-arid to sub-humid and temperate, the floral composition is likewise varied and diverse. The formations present within this zone are characterised essentially but not exclusively by the following species: *Tetraclinis articulata*, *Quercus coccifera*, *Quercus rotundifolia* and *Quercus suber*. In addition, the vegetation that flanks valley systems and their floodplains is characterised by the Nerio-Tamaricetea formations with, to a lesser extent, elements of Mediterranean riverine assemblages dominated by species of *Fraxinus* and *Salix*. Closer to the coastal fringe, the vegetation is dominated by a halophilic suite of species, notably *Juncus* (mainly *J. rigidus*) and *Salicornia* spp. together with *Tamarix* spp. (Barbero & Quézel 1981, Asensi & Diez Garretas 1987, Martinez-Parras & Peinado Lorca 1987)

MATERIAL AND METHODS

The headwaters of Oued Laou are located some 70 km from the Mediterranean coast at an altitude of 1600 m on the slopes of Jbel Tissouka, in addition to which, other major valley systems drain into the Oued Laou basin. These include Oued Tassikesté, Oued Farda, Oued Kalaa, Oued Essarem, Oued Talambote, Oued Moulay Bouchta, Oued Ouara and Oued Maggo (Maurer 1968, André 1971).

The resulting microclimate of the region varies from humid to hyper-arid, depending on the time of year consistent with pluvio-thermal patterns and altitude. On a broader scale, the coastal area and the mountainous hinterland of the basin have a considerably varied climatic gradient. The latter region demonstrates a wetter and colder clime typical of Mediterranean mountainous areas while the coast experiences a warmer climate with a markedly high relatively humidity. Rainfall within the hinterland region varies between 800 mm and 1400 mm (e.g. Bab Taza rainfall averages 1361 mm) and it is predicted that the higher mountain summits in the area exceed 2000 mm of rainfall. On the other hand, rainfall in coastal areas does not usually exceed 500 mm (rainfall at Oued Laou town averages 473 mm). As a consequence to the different characteristics of the region, notably its geology, geomorphology and hydrology, its biogeography (zone 1 Rif-Tazekka) and its climatic regime, the Oued Laou basin has a remarkably rich and diverse flora. The vegetation within the basin is sub-divided into different zones, depending largely on altitude and in which diverse floral patterns emerge (Mazzoleni *et al*. 2005).

Fieldwork was carried out during the months of April and May of 2004, although other field visits were conducted in December of 2003 and June of 2005. The research mission was carried out in conjunction with a nine-day field meeting that was coordinated by the Faculté des Sciences of the Université Abdelamalek Essaadi (Tétouan) and the Institut Scientifique of the Université Mohammed V – Agdal (Rabat), during which a multidisciplinary team of over forty researchers from participating entities cooperated during field sessions. A number of research stations were identified across the thermo-Mediterranean zone of the Oued Laou basin during the initial days of the field meeting (Fig. 1), when a familiarisation exercise was carried out with a view to assess the region. The description of studied stations is indicated in table 1.

Biotopes were characterised by visual appraisal during standard searches or walkover surveys, on the basis of geomorphological features and existing plant communities in view of the fact that these are rooted in place, permanently or seasonally. The reason for paying particular attention to the flora is based on the fact that plants are the prime determinants of most local biotopes and, above all, because animal life depends on plant life. Assessment of plant communities and assemblages colonising the various research stations was carried out through a straightforward census of species that were dominant, in terms of abundance and estimated biomass (Braun-Blanquet 1932). In a number of instances, characterising species that define a biotope were identified, notwithstanding that these were not in leaf at the time of survey, on the basis of woody plant structures or dry aerial remains.

Based on field identification, floral assemblages were assessed on the strength of species present, noting in particular dominant, characterising and indicator species, while also recording accompanying species. However, no attempt at compiling an exhaustive inventory of species was made since such an exercise would require extensive sampling using a variety of techniques and carried out during different times of the year. Each community was identified by its representative species and, as outlined above, exhaustive species lists were not compiled since this was considered to be outside the scope of initial characterisation and categorization. A constraint often encountered during such characterisation field exercises of biotopes and community types is that ecosystems do not have clean-cut boundaries but grade into one another. This is understandable when one considers that biotic communities are assembled primarily as a function of the individual species' environmental requirements, thus, local variations in environmental variables often lead to the presence of mosaics of different species assemblages. Intense human interference with natural and semi-natural biotopes often leads to the introduction of alien elements, resulting in a 'mixing' or merging of community types.

Figure 1: (left) Satellite image of the Oued Laou basin indicating position of research stations; (right) general view of lower regions of the area of study.

Table 1. Details of the transects undertaken at five research stations during the 2004 field meeting.

Stations	Biotopes
Station 1: Oued Laou river channel cross-sectional transect Coordinates : N35° 21' 46.2" W05° 10' 41.4" (at road) Transect orientation : ESE 105° – WNW 285°	Arbor-vitae matorral (Thermo-mediterranean arborescent matorral of North Africa dominated by *Tetraclinis articulata*), with Thermo-Mediterranean brush based upon *Pistacia lentiscus*, *Calycotome villosa*, and Palmetto brush - *Chamaerops humilis* with understory of *Cistus albidus*, *Lavandula stoechas* and *Cistus monspeliensis;* and, *Nerio-Tamaricetea* formation nearer the river channel.
Station 2: Marsh at Oued Laou estuary Coordinates : N35° 26' 09.2" W005° 04'51.4" Three belt-transects each 1m wide and varying in length	Mediterranean tall rush saltmarsh (*Juncion maritimi* based upon *Juncus rigidus*) with Halophile clubrush beds (*Scirpion maritimi*) and *Scirpo-Phragmitetum.*
Station 3: Kaa Asras floodplain Coordinates : N35° 25' 24.2" W05° 06' 33.6" Transect orientation : NNE 15° – SSW 195°	*Nerio-Tamaricetea* formation with Riparian willow formation (*Salicetea purpureae*).
Station 4: Ifansa - Laou river channel Coordinates : N35° 17' 57.8" W05° 13' 04.7" Transect orientation : NNE 10° – SSW 190° 1st alignment Coordinates : N35° 17' 59.4" W05° 13' 04.3" Transect orientation : NW 320° – SE 140° 2nd alignment	Arbor-vitae matorral (Thermo-mediterranean arborescent matorral of North Africa dominated by *Tetraclinis articulata*), with Thermo-Mediterranean brush based upon *Pistacia lentiscus* and Palmetto brush - *Chamaerops humilis* with understory of *Cistus monspeliensis*; and, *Nerio-Tamaricetea* formation nearer the river channel and *Nerion oleandri* communities dominated thickets on tributary.
Station5 : Ifansa – woodland Coordinates : N35° 17' 46.5" W005° 13' 35.2" Transect orientation : NE 60° – SW 240° NNW 330° – SSE 150° Band transect 20 m x 15 m	*Quercus ilex* forests (typical of the Meso-Mediterranean holm-oak forest formation) - *Quercion ilicis* with *Arbutus unedo* and Lentisc arborescent matorral characterised by tall *Pistacia lentiscus*.

At some of the research stations (1, 3 and 4), where this approach was deemed relevant, one or more transects were made with a view to acquiring a topographic profile and one that reflected the vegetation cover (Fig. 2). The objective of two transects across the same profile, i.e., one for topography and the other for vegetation, was essentially to superimpose the pattern of floral distribution onto the topographic outline. Thus, the line intercept method was employed to survey the terrain (break-of-slope approach) across the selected research station, using a clinometer, tape measure and compass, and the vegetation present along the transect. In some cases, as in stations 2 and 5, the method employed was that of a band or belt transect rather than a simple line intercept as at research stations 1, 3 and 4. Since the terrain at research stations 2 and 5 was flat, and, as detailed above, relatively short belt/band transects were employed, it was decided not to chart the topographic profile at these stations.

In addition, the beach at Oued Laou locality and four of the research stations described above (namely, research stations 2, 3, 4 and 5) were assessed in terms of their dipterous fauna with a view to make general observations and record bio-indicator species within the different biotopes studied. Research station 1 was considered inappropriate for sampling diptera due to its precariously acute slopes, thus rendering the terrain unsuitable for collecting. Collecting involved walkover surveys during daylight hours, mostly by sweeping the terrain and its vegetation cover, with a hand-held net in each of the biotopes and their immediate surroundings, as well as stalking individual flies where this was deemed appropriate. The material collected was prepared in the field to provide specimens in optimum condition for identification. Every effort was made to identify as much of the material as current knowledge and available resources permitted.

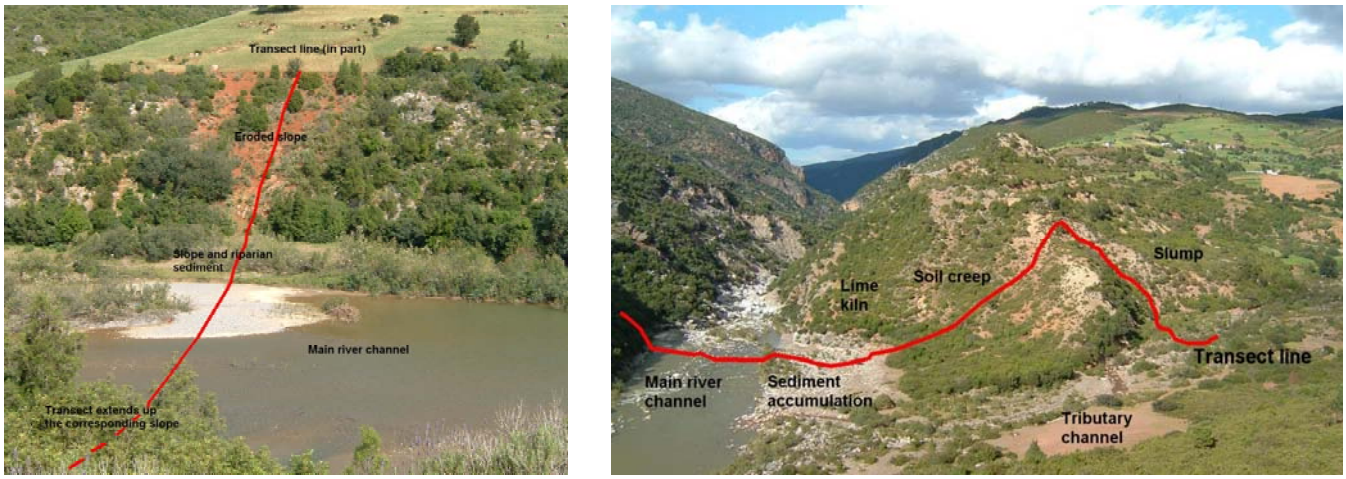

Figure 2: (left) Laou river channel view with superimposed transect (research station 1); (right) Ifansa landscape with superimposed transect (research station 4).

RESULTS AND DISCUSSION

The terrain within the thermo-Mediterranean zone at Oued Laou supports a variety of biotopes, their range and extent largely dependent on edaphic factors and other environmental conditions consistent with relief and hydrography. From field observations and subsequent findings, it is evident that the hydrological regime exerts a significant influence on the landscape within the Oued Laou basin, both in terms of distribution patterns of vegetation types and land-uses. From the point of view of the anthropic land-cover, the river channel, its tributaries and floodplain regions bring to bear a land-use regimen that respects cyclical events of the basin's hydrology. From the vegetation standpoint, the floral patterns of distribution and assemblage make-up are generally consistent with soil-water relationships. For example, the biotopes that colonise the lower reaches of the basin, where temporary or semi-permanent inundation prevails, are chiefly made up of host of species characteristic of wetlands (including marshes, perennial courses, seasonal run-off conduits and floodplains) and a suite of species typical of environmentally disturbed habitats, as a result of regular natural upheavals caused by cyclical fluvial episodes (e.g., torrents, mudslides and floods).

Primarily, the biotopes of the lowlands within the basin comprise *Juncion maritimi* based upon *Juncus rigidus* - Mediterranean tall rush saltmarsh, with Halophile clubrush beds (*Scirpion maritimi*) and *Scirpo-Phragmitetum*; Nerio-Tamaricetea formations, in places with riparian willow formation based upon *Salicetea purpureae*; and, *Nerion oleandri* thickets, mostly on areas that experience temporary inundation such as floodplain zones, seasonal tributaries and river banks. Other less flood-prone areas within the thermo-Mediterranean zone tend to be colonised by assemblages that are typical of drier, almost arid, habitats. These consist of Arbor-vitae matorral made up of Thermo-Mediterranean arborescent matorral of North Africa dominated by *Tetraclinis articulata*, with Thermo-Mediterranean brush based upon *Pistacia lentiscus*, *Calycotome villosa*, and Palmetto brush - *Chamaerops humilis* with understory of *Cistus albidus*, *Lavandula stoechas* and *Cistus monspeliensis* (Devillers & Devillers-Terschuren 1996, European Commission DG Environment 1999).

The transect profile plotted at **research station 1** follows a cross-section of the river channel and banks. The terrain consists of a relatively steep slope on the east-south-east sector, averaging a 38^{o} slope angle; the river-course (at the time of survey, this sector of the area of study comprised a shallow pebble-bed mostly navigable on foot); and the opposite west-north-west bank with an average slope of 24^{o}. The land-cover further up from the end of the transect on the WNW bank, consists of terracing and cereal cultivation.

The biotopes within the east-south-east acutely sloping banks of research station 1 are mostly based on *Tetraclinis articulata* of the Thermo-Mediterranean arborescent matorral characteristic of Mediterranean North Africa and some parts of Andalusia. In fact, with the exception of *Lavandula stoechas*, which forms an extensive understory layer, *Tetraclinis articulata* was found to have the highest coverage in terms of extent (see Fig. 3). The thermo-Mediterranean brush, in this case based upon *Pistacia lentiscus*, *Phillyrea* sp., *Arbutus unedo*, *Ceratonia siliqua* and *Calycotome villosa*, is largely dominated by *Pistacia lentiscus*, which also forms a significant cover. *Chamaerops humilis*, which characterises the Palmetto brush, is best represented within the Mediterranean region of North Africa besides other Mediterranean coastal localities. It is relatively well represented within this research station, forming stumps throughout much of the upper reaches of the transect. The understory layer, again on the upper reaches of the profile, is characterised by *Lavandula stoechas*, *Cistus albidus* and *Cistus monspeliensis*.

The floral list of species on the opposite west-north-west bank is more-or-less similar although the distribution profile was quite different, probably as a result of human disturbance through cultivation and grazing. As a consequence, the vegetation comprises *Chamaerops humilis* and *Urginea maritima*, species that withstand

grazing pressures, *Galactites tomentosa*, a pioneer species that indicates degradation and disturbance, *Lavandula stoechas*, *Cistus albidus* and *Cistus monspeliensis* representing the main coverage, and only a handful of *Tetraclinis articulata* and *Pistacia lentiscus.*

The lower reaches of the riverbanks as well as the midstream shingle-banks are mostly colonised by Nerio-Tamaricetea formations, dominated by *Tamarix africana* with *Nerium oleander* and, to a lesser extent, with *Juncus rigidus.*

Research station 2, located near the mouth of the river channel, comprises an estuarine formation with a gradation of sediment on its meandering banks, ranging from fine silt to shingle. Vegetation cover within the estuary zone varies depending on location; where the flow of water is sluggish, vegetation was noted to colonise the banks successfully while, where fast-flowing waters scour the embankments, the riverbanks are for the most part devoid of vegetation growth. The biotopes at research station 2 consist of Mediterranean tall rush - *Juncion maritimi* based upon *Juncus rigidus*, with Halophile clubrush beds (*Scirpion maritimi*) and *Scirpo-Phragmitetum*; Nerio-Tamaricetea formations and a suite of species typical of environmentally degraded terrain as a result of episodic disturbance by floodwaters.

As indicated in the methodology above, three belt transects of one metre width but varying in length were employed at this research station. Belt transect 1 (Fig. 4a) was 5 m in length, belt transect 2 (Fig. 4b) was 10 m in length and belt transect 3 (Fig. 4c) was 4 m in length. The length of the transects varied due to the winding nature of the banks. Furthermore, as a consequence to the flat characteristics of the terrain at the estuary, it was deemed unnecessary to determine the topographic profile along with the vegetation profile. Thus, rather than profiling the vegetation inland from the banks, the orientation of the three belt transects at this research station was parallel to the river-course since the natural assemblages present occupied the immediate banks. Beyond the narrow band of riverbank vegetation, the terrain is sparsely vegetated by a host of species typical of a degraded environment, possibly as a result of grazing pressure, trampling as well as cyclic flooding episodes.

Belt transect 1 demonstrates a high frequency of *Juncus rigidus*, which indicates a relatively stable environment immediately on the riverbanks, accompanied by a somewhat small amount of inland-occurring species (Fig. 4a). *Aster squamatus*, an opportunistic alien species and an indicator of habitat instability, whose coverage on the inland segment of this belt transect is also relatively significant, illustrates evidence of disturbance of the terrain.

Belt transect 2 is more species rich than the previous but the general composition is more or less similar. The bar-graph below (Fig. 4b) illustrates the assemblage is dominated, as in the previous belt transect, by *Juncus rigidus* on the segment nearer the river-course, with elements of the *Scirpion maritimi* and *Scirpo-Phragmitetum* formations based upon *Phragmites australis*, *Scirpus lacustris* and *Thypha domingensis*. These species tend to become more common around relatively inaccessible sandbanks and canals that occur in various regions of the estuary. The inland and more consolidated segment of the belt transect is largely colonised by *Plantago coronopus* s.l. and *Cynodon dactylon* among other species.

Belt transect 3 (Fig. 4c) demonstrates a somewhat different floral make-up than the preceding two belt transects. The location of this belt transect was within 22 m of belt transect 2 and upstream of both of the initial two transects. Also, the level of the ground at this belt transect was noted to be slightly higher from water level than in the previous two transects.

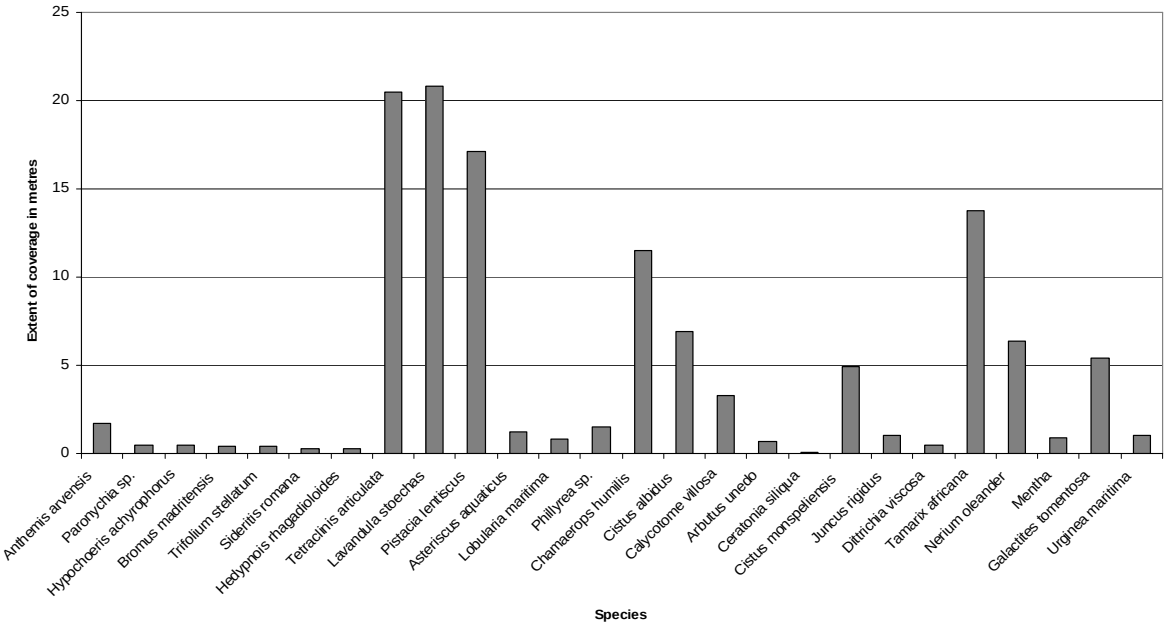

Figure 3: Floral coverage at Laou river channel – Research station 1.

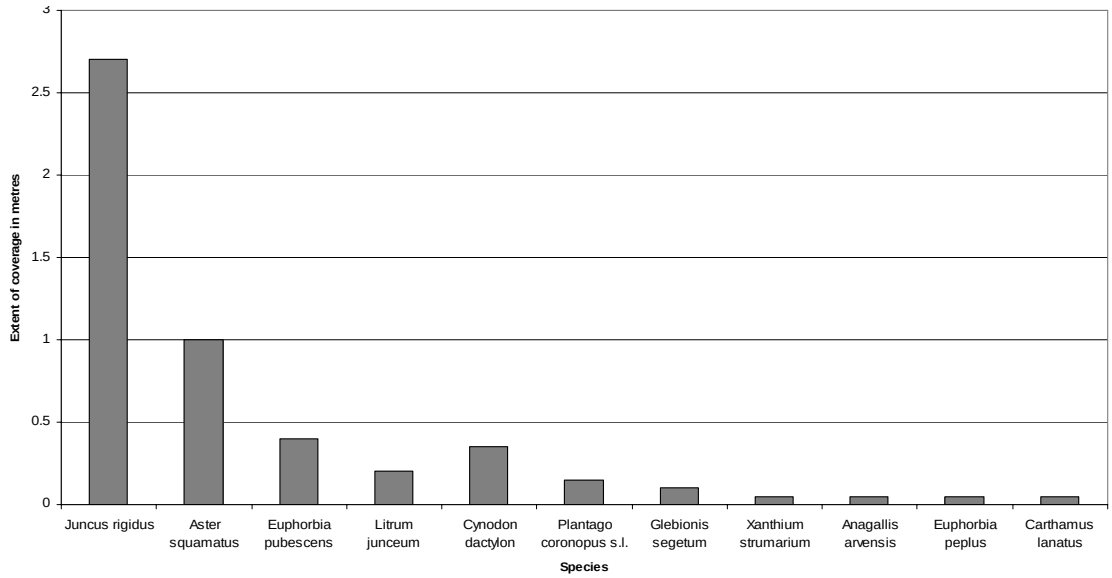

Figure 4a: Floral coverage at marsh at Oued estuary – Research station 2, Transect 1.

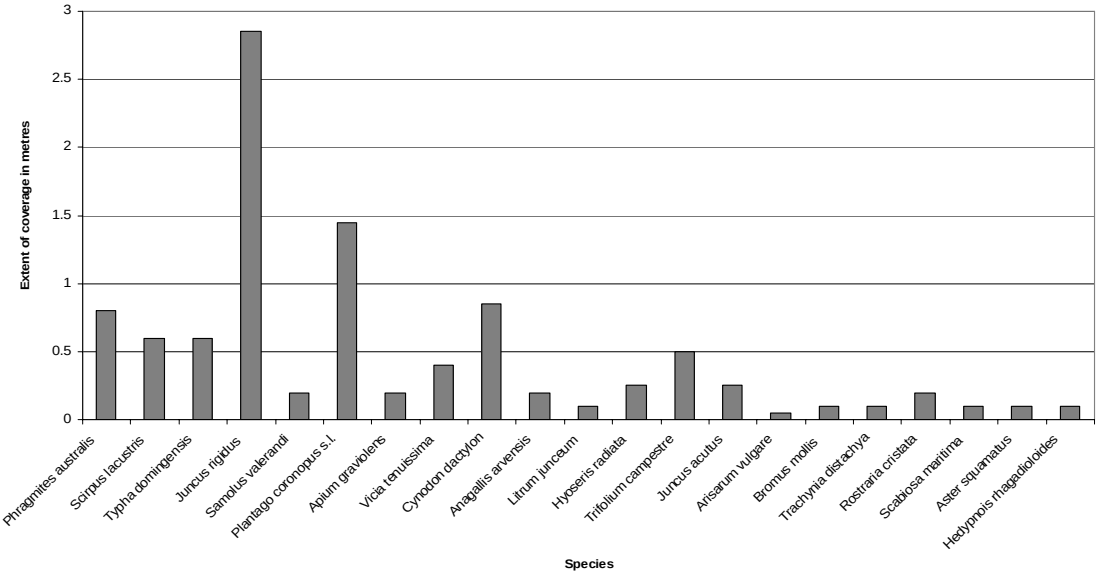

Figure 4b: Floral coverage at marsh at Oued estuary – Research station 2, Transect 2.

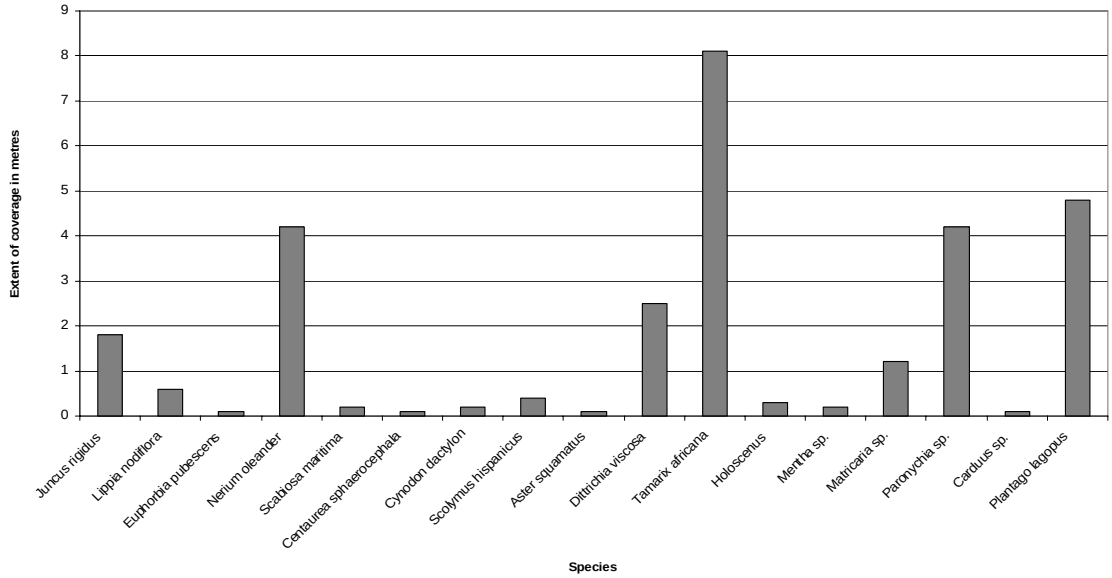

Figure 4c: Floral coverage at marsh at Oued estuary – Research station 2, Transect 3.

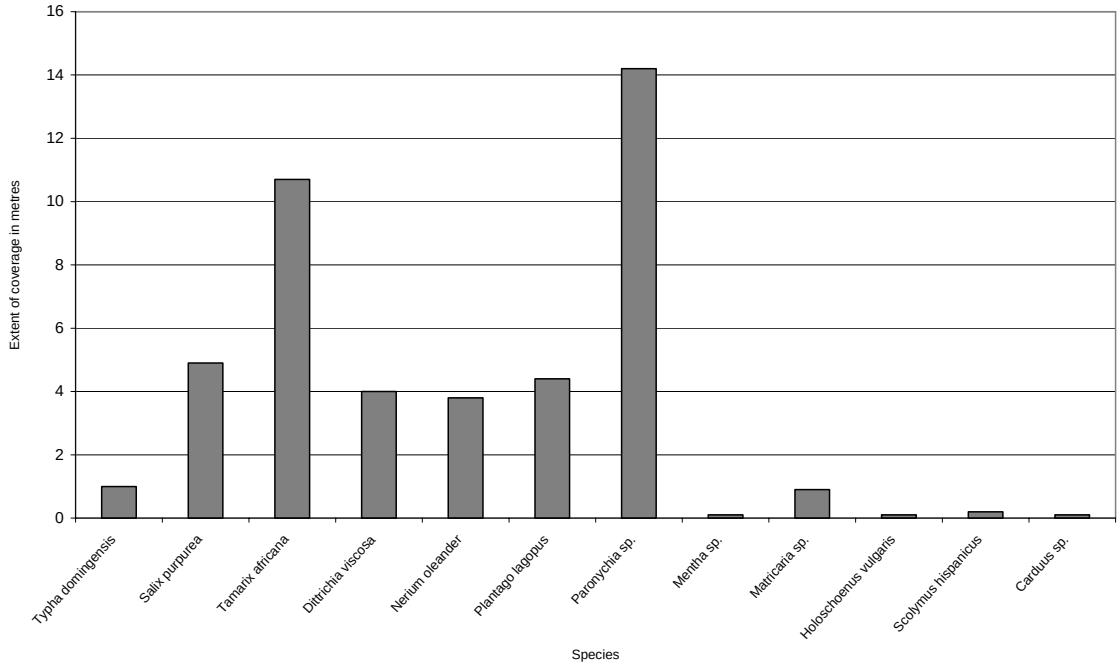

Figure 5: Floral coverage at Kaa Asras floodplain – Research station 3.

The main assemblages within this transect comprise the Nerio-Tamaricetea formation, which colonises the segment closer the river-course, and a suite of species that colonise sections of the consolidated segment inland of the tamarisk (*Tamarix africana*) and oleander (*Nerium oleander*) formation. This latter assemblage consists of *Plantago lagopus*, *Dittrichia viscosa* and *Scolymus hispanus* indicating a degree of disturbance as well as consolidation of sediment, most likely through grazing and trampling by goat herds. Other species with demonstrated significant coverage are *Paronychia* sp. and *Juncus rigidus.*

The sum total of spatial coverage by different species recorded exceeds that of 19 m (the total distance covered by the three belt transects), as there are elements of overlap with different floral species colonising the same spatial areas. More than 8 m were colonised by *Tamarix africana*, some 7.35 m were colonised by *Juncus rigidus* and 4.2 m by *Nerium oleander*. Other species that characterise the riparian environment of the estuary, whose total spatial coverage was 6.4 m, include *Paronychia* sp., *Phragmites australis*, *Thypha domingensis*, *Scirpus lacustris* and *Juncus acutus.* Moreover, a suite of species, made up of a flora that would typically colonise degraded and/or consolidated sediment environments, cover proportionately less significant spatial areas. The total coverage for *Plantago lagopus*, *Dittrichia viscosa*, *Plantago coronopus* s.l., *Cynodon dactylon* and *Aster squamatus* was 11.5 m.

Research station 3 consists of a somewhat flattish profile measured on the river channel's floodplain in the vicinity of the village of Kaa Asras (see table 1 for coordinates). The length of the line transect, whose orientation was from NNE to SSW, totalled 44.3 m. The overall height of this transect above the water level averaged approximately a metre, although the point furthest inland rose to just over 3 m. The general texture of the surface sediment throughout the transect consisted of a fine sand as a result of alluvial processes at this sector of the area of study.

The vegetation largely comprises species typical of a riparian environment (Fig. 5), with a floral range exhibiting an interesting gradient, with *Salix purpurea* colonising the riverbanks, along with *Typha domingensis* and *Nerium oleander* on the immediate river-bank interface, the *Nerio-Tamaricetea* formation on the flatter plain further inland, and large concentrations of *Paronychia* sp., on an inland pebble bed that runs parallel to the river course. *Mentha* sp., and *Holoscenus* sp., also occurs. *Tamarix africana* and *Nerium oleander* individuals within this research station were noted to be quite large and well-established. Clumps of *Dittrichia viscosa*, which indicate a degree of disturbance, are potentially the result of combined natural (intense runoff surges) and human (trampling/grazing) influences. Such clumps have a total coverage of 4 m and occur primarily in areas conducive to natural flooding and human access; the latter flat and somewhat open expanses are also extensively colonised by *Plantago lagopus*.

The transect at **research station 4** represents a cross-section of the terrain and of the thermo-Mediterranean arborescent matorral (accompanied by an understory of *Cistus* garrigues), and the Nerio-Tamaricetea formation, vegetation typical of the Oued Laou basin thermo-Mediterranean zone. This transect extended over almost 250 m (equivalent to 286 m in terms of horizontal distance) and included a seasonal wadi bed, a hillock and a section of the river course. In view of the extensive length of this transect, it was deemed necessary to alter orientation at one point (at approximately 60 m distance from the zero point). The line transect was therefore initially oriented NNE10°-SSW190°, and subsequently oriented NW320°-SE140°. The overall height of the transect measured over 40 m, with the zero point taken to be the wadi bed (seasonal watercourse), which was just over 20 m above the river

course, and over 20 m below the peak of the hillock. The south-facing slope of the hillock was considerably steeper than the north-facing slope, which had a gentler gradient towards the river course.

The plant communities at research station 4 may be divided into two, notably, the thermo-Mediterranean arborescent matorral, which colonises the hillock, and much of the undulating terrain which characterises the landscape within this sector of the basin, and the Nerio-Tamaricetea formation, which characterises the riparian environment at this research station (including the seasonal wadi bed and the river banks). From various visits to this location, it is evident that water levels and flow rates, even of the main river course (Oued Laou), fluctuate significantly over different seasons. At the time of survey, at the end of April (2004), the main river course was a raging torrent, while in June (2005) water flow rate was reduced considerably to the level of a gentle stream.

From fieldwork findings, it is evident that two main biotope-types occur. The lower, flatter, and more humid areas within this research station, where inundation occurs, are largely colonised by *Nerium oleander*. As Figure 6 indicates, this species has an extensive coverage, indeed close to 60 m in total linear coverage across the transect. *N. oleander* was noted to colonise two principal areas, namely the wadi bed which functions as a water runoff conduit or minor seasonal tributary, and on the immediate silted banks of Oued Laou proper. From the water-eroded boulders and pebbles present, it is apparent that these banks constitute the flood plain of the river. Other species that occur within this environment include *Tamarix africana*, which forms an integral part of the Nerio-Tamaricetea formation and a species of *Carex* that formed tussocks within the silted riverbank, together with *Dittrichia viscosa* that colonises the less humid silted areas and which indicates a degree of disturbance as a result of fluvial and sediment fluxes.

The arborescent matorral is characterised by *Pistacia lentiscus*, which, together with *Tetraclinis articulata*, forms the basis of this biotope. The former has an extent of over 100 m in terms of linear coverage, while the latter species has an extent of approximately 50 m. The understory formation is composed of a diverse array of species of the thermo-Mediterranean brush and heath garrigues, comprising *Erica* sp. formations, *Chamaerops humilis*, *Calycotome villosa*, together with elements of the *Cistus* garrigue, based upon a significant presence of *Cistus monspeliensis*, accompanied by *Cistus albidus*. It should be pointed out that the '*Tetraclinis* biotope' is exceedingly widespread throughout the region. However, it should also be noted that land-cover occupied by this biotope is one most popularly used for grazing purposes.

As noted in the methodology above **Research station 5** was investigated by means of a band transect, which measured 15 by 20 m on a NE60°–SW240° plain. This research station comprised a section of the woodland biotope on the upper reaches of the hills around Ifansa. The terrain of the band transect was on the 10˚ slope, ascending in a SSE direction.

The vegetation at this research station consists of species that make up the woodland canopy. At the time of survey, there was no understory of significance. Of species noted, the only species that could remotely be associated with the understory layer is the clambering *Smilax aspera* which colonises the regions around tree trunks and the lower branches of the trees present. The main tree cover is dominated by *Arbutus unedo* and *Quercus ilex*, together with *Quercus suber*, while the sub-canopy comprises *Pistacia lentiscus* and *Myrtus communis*. This biotope is widespread in three main characteristic areas, namely at higher altitudes of the thermo-Mediterranean zone, where the soil cover is relatively thick, and where the relief provides shelter from prevailing winds that funnel through the Oued Laou basin. Such forested terrain is particularly important to bind sediment and soil and prevent mass movements such as slope failure that produces mudslides, landslides and rockfalls.

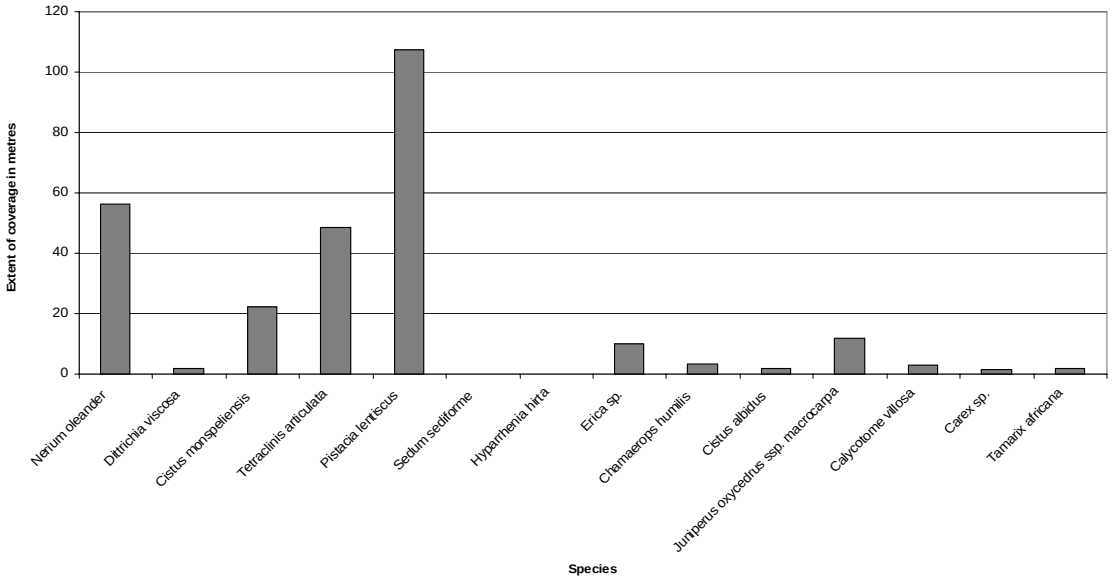

Figure 6: Floral coverage at Ifansa - Laou river channel – Research station 4

Table 2: Diptera taken at research stations. (* some species were common to two or more of the stations)

Family	Beach	Station 2	Station 3	Station 4	Total no. of species
Agromyzidae	2	0	0	0	2
Anthomyiidae	1	1	4	2	8
Asilidae	0	0	1	3	4
Asteiidae	1	0	0	0	1
Bombyliidae	1	2	2	0	5
Calliphoridae	1	2	5	4	8
Carniidae	0	0	1	0	1
Chloropidae	4	3	3	0	10
Chyromyidae	0	1	0	0	1
Dolichopodidae	4	5	4	4	14
Drosophilidae	2	1	0	0	3
Empididae	0	4	4	5	13
Ephydridae	9	8	5	3	19
Fanniidae	0	0	4	0	4
Hybotidae	1	11	9	2	23
Keroplatidae	0	0	1	0	1
Lauxaniidae	0	2	3	1	6
Lonchaeidae	0	1	1	0	1
Lonchopteridae	1	1	0	0	1
Milichiidae	0	2	0	0	2
Muscidae	0	10	13	4	22
Mycetophilidae	0	0	0	1	1
Phoridae	0	0	1	0	1
Ulidiidae	0	0	2	1	2
Sarcophagidae	1	4	3	2	8
Sciomyzidae	0	1	2	1	3
Scatopsidae	0	1	0	0	1
Sepsidae	0	0	1	0	1
Simuliidae	0	0	1	0	1
Sphaeroceridae	4	12	12	0	23
Syrphidae	0	3	5	0	7
Tabanidae	0	0	0	1	1
Tachinidae	0	o	5	3	7
Tephritidae	2	3	3	0	5
Tethinidae	3	2	0	0	4
Therevidae	0	1	0	0	1
Trixoscelididae	2	1	0	0	3
No of species	39	82	95	37	218*

Diptera (Insecta) as bio-indicators

Diptera were sampled with a view to establish whether the biotopes at the different research stations were colonised by stenotopic species, that is by bio-marker species that were solely adapted to the particular biotope that characterised each of the research stations within the thermo-Mediterranean zone of Oued Laou. A total of 218 species of diptera in 37 families were collected from the beach and from stations 2, 3 and 4. The results are tabulated (Table 2) with families of diptera listed in alphabetical order, together with the actual number of species collected in each family. Station 3 was the most diverse in terms of the number of species (44% of the total number of species encountered) followed by station 2 (38% of the total number of species encountered). The beach yielded 18% of the total number of species encountered, while station 4 was the least diverse with 17% of the total number of species encountered. No diptera were encountered at station 5.

In terms of diptera biodiversity, the area is considered relatively poor. In comparing these types of biotopes and associated landscapes at Oued Laou with other localities in the Mediterranean, in both the western and eastern basins, one would have expected more diversity. For example, some families of diptera such as the *Chironomidae*, prominent in similar biotopes in the Mediterranean, were completely unrepresented in this study. Other large and important families with aquatic immature stages, such as the *Culicidae* and *Stratiomyidae* were not even encountered. In general most families of diptera were under-represented. On the other hand, two families, the *Calliphoridae* and *Muscidae*, were well represented, with 8 and 22 species respectively. Possible factors for such scarcity include extensive agricultural practice and use of pesticides in the general area of study, absence of *Posidonia* banquettes on the beach and sparse vegetation cover on the beach.

Out of a total of 39 species collected on the beach, 11 species are considered to be truly stenotopic, that is, confined to beaches. These are *Chersodromia albopilosa* Chvála, *Fucellia maritima* (Haliday), *Glenanthe ripicola* (Haliday), *Hecamede albicans* (Meigen), *Psilopa maritima* (Perris), *Tethina albosetulosa* (Strobl), *T. longirostris* (Loew), *T. ochracea* (Hendel), *Thoracochaeta brachystoma* (Stenhammar), *Trixoscelis approximata* (Loew) and *T. laeta* (Becker).

CONCLUSION

The present study serves as a baseline record of the characteristic vegetation of the Oued Laou basin. As the results demonstrate, there is a range of biotopes present within the thermo-Mediterranean zone, which are found in different segments of the Oued Laou basin, owing to the heterogeneity of abiotic environments present. With respect to the latter, water flow through the oued clearly plays a key role in determining vegetation composition and extent, and, owing to seasonal fluctuations in water levels, such baseline studies could therefore be replicated at different times of year. Indicators of disturbance were noted during the survey, relating both to natural disturbance (namely flooding) and anthropic disturbance from the range of activities occurring within the basin. With regard to the latter, it is recommended that future studies establish a baseline for landscape which would incorporate the vegetation findings discussed above; this would serve as a standard against which to measure the impact of human activities, which, given trends elsewhere in the Mediterranean, can only be expected to increase.

Acknowledgements

This research was funded by the European Union, 6th Framework Programme, MED-CORE Project Contract ICA3-CT2002-10003 (2002-2004). The authors would like to extend their thanks to Professor Abdellatif Bayed, Professor Mohamed Ater, Professor Felicita Scapini and Dr Lorenzo Chelazi.

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Manuscrit reçu le 12 janvier 2007