

Chapter 3

MEDITERRANEAN CLIMATE RIVERS OVER THE WORLD:
convergences and divergences between regions¹.

INTRODUCTION

Mediterranean regions and climate

There are five regions over the world present a mediterranean climate (called med-regions). They are located between 32°-40° N and S of the Equator, in the west side of continents (Aschmann, 1973a): Mediterranean Basin, California, Chile, South Africa and Australia (the South-West and South). All these areas represent between 1% and 4% (di Castri, 1981; Mooney, 1982) of the earth surface (Figure 1). However, there are discrepancies among geographers, physics or biologists in the description and delimitation of extension of mediterranean climates (Nahal, 1981).

The mediterranean climate is defined in terms of precipitation (di Castri, 1973a) and temperature (Aschmann, 1973a), and it is characterized by a high seasonality (Paskoff, 1973; Daget & Michel-Villag, 1975) summarized as hot and dry summers and cool and wet winters (Köppen, 1923). Winter temperatures are mild (7-13°C) with frosts and snow infrequent,

¹ Mediterranean is written with “M” when is referred to the Mediterranean Basin, and with “m” when it speaks of the climate.

whereas summers are hot with a mean temperature of 14-25°C (Paskoff, 1973). On the other hand, precipitation it is highly variable along and between years (Paskoff, 1973; Nahal, 1981), implying a high climatic heterogeneity either along time and space (Mount, 1995). The annual range of precipitation goes from 275 to 900mm/y, although several authors define the climate only using the minimum (see Conacher, 1995; Conacher & Sala, 1998). Most of rainfall falls during winter months, and this is one of the key elements to distinguish between mediterranean, temperate and subtropical climates (Dept. Land Affairs, 1994). According to Aschmann (1973a) more than 65% of annual rainfall should fall in winter, although in some areas this is not as strict (Köppen, 1923; Specht, 1979) with important spring and autumn rains (Southern California and Southern Europe —Miller, 1983). During summer, a drought period is present with length and intensity variable between years (di Castri, 1973a, 1981).

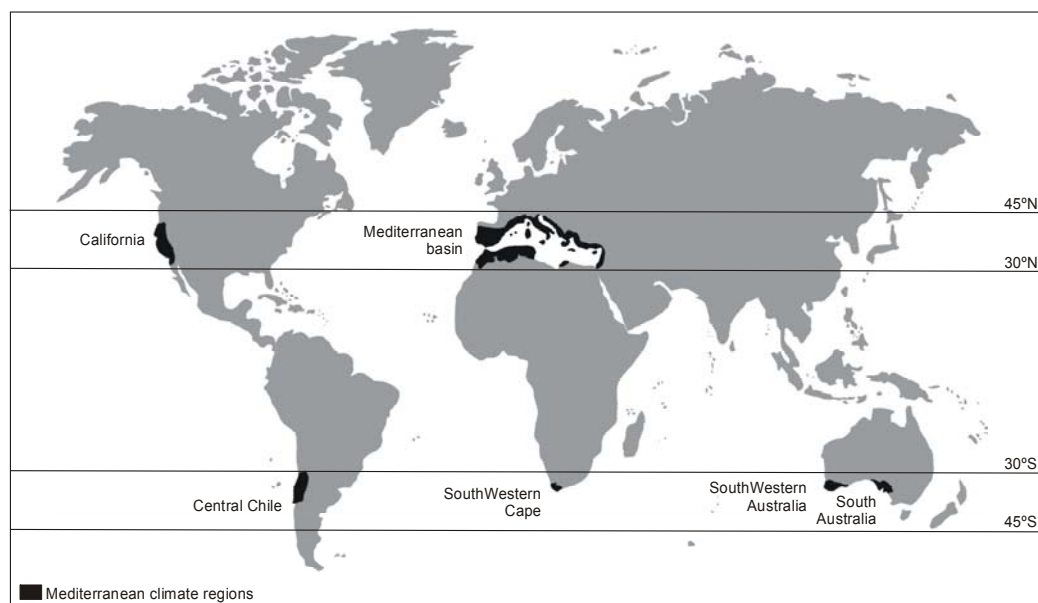


Figure 1. Map of the distribution of mediterranean climate over the world.

Although there are many common climatic characteristics among med-regions, local climate is modified by orography, altitude, orientation from coast line, continent and oceanic influences... (Aschmann, 1973a; Conacher & Conacher, 1998), and therefore several microclimatic patterns can be established (Nahal, 1981; Daget *et al.*, 1988). Köppen (1923) distinguishes between hot and cold summers, and Emberger (1930, 1955, and 1971) defines 6 types of subclimates according to its humidity and the winter severity: subdesertic or periarid, xeromediterranean or arid, termomediterranean or semiarid, mesomediterranean or

subhumid, submediterranean or humid and subxeric or perhumid. However, from these subclimates Di Castri (1973c) distinguished an “eumediterranean” subclimate which would be equivalent to the semiarid and subhumid subclimates, with a precipitation range of 275-640mm/y.

Mediterranean climate is located between the temperate and dry climate areas (see Dallman, 1998), and both regions have influenced strongly the mediterranean climate and its present biota (di Castri, 1981; Herrera, 1995). Relationships with these adjacent climates are variable between regions (di Castri, 1981). For example, summer precipitation is higher in South Africa and northern Mediterranean Basin because of their proximity to tropical and temperate regions, and lower in Chile because of Atacama Desert influences (di Castri, 1981).

Mediterranean biota and humans

Mediterranean climate originated in the Pliocene, 3.2 My ago (Alxelrod, 1973; Suc, 1984), and therefore is a young climate in geological terms, younger than part of the biota found in these med-regions (Raven, 1973). As a consequence, some lower vertebrate, invertebrate and plant distributions are homogeneous, reflecting the patterns established during the Mesozoic, before the breakup of the continents and the formation of the mediterranean climate (Deacon, 1983; Herrera, 1995), or the later connections between regions (Nilsen, 1978; Cooke, 1972). Once the climate was formed, similar selection forces acted in the configuration of the mediterranean biota (Johnson, 1973), and therefore, a high similarity between regions should be expected (Mooney, 1982). However, mediterranean areas in the world show an important variability in ecosystems, because of geographic, microclimatic, topographic, physiographic, litologic and historic aspects have contributed to the present faunal and floral distributions (di Castri, 1981). Several authors suggest 4 origins of the mediterranean biota (di Castri, 1991):

- Species developed *in situ* before the mediterranean climate formation.
- Species developed after the mediterranean climate was established.
- Species developed outside the mediterranean regions but that settled in these areas posteriorly.
- Invasive species from human impact.

When biota is compared among med-regions, all these possible origins must be considered and specially the historical or environmental factors (di Castri & Hadley, 1985; di Castri, 1991).

When first explorers arrived into the Cape region, central Chile, California and Australia, noted a high resemblance between these regions with the Mediterranean Basin (di Castri, 1981). However, the biogeographical concept of mediterranean biome was established a century later by Grisebach (1872), Drude (1890) and Schimper (1898), based on the similarities between vegetation in mediterranean areas. First comparative studies in these med-regions derived from botanical aspects (Spetch, 1979; Specht & Rayron, 1957; Specht, 1973; Cody & Mooney, 1978) revealing a high similarity in plant morphology and structure (Mooney and Dunn, 1970), with a sclerophyllous and evergreen vegetation (Kummerow, 1973; Mooney, 1977, 1982; Rundel, 1988). Duration of the summer drought and the cold in winter seem the ecological factors more likely to provide this similarity (Aschmann, 1973a; Nahal, 1981; Orshan, 1983; Miller, 1983). Both phenomena imply a continuous and predictable natural disturbance, where the evolution took place (Stanford & Ward, 1983), and developing plant communities with common characteristics with different names: chaparral in California, maquia or matorral in the Mediterranean Basin, matorral in Chile, fynbos in South Africa and health or mallee in Australia (Naveh & Whittaker, 1979). Some studies indicate that this type of vegetation and structure is not exclusive from the mediterranean region, with some extensions through areas with high summer rainfall in the east of Australia (Specht, 1979), Mexico (Muller, 1939) or east Africa (Rundel, 1988).

In spite of these similarities, some differences are present because of local factors as human impact, soil nutrients (Specht, 1979; Mooney, 1982; Specht & Moll, 1983), humidity (Beard, 1983), natural history (di Castri, 1973b) or landscape orography (Cody, 1973; Mooney, 1977; di Castri, 1981). However, as a general rule, mediterranean regions are richer in species than the adjacent ones (e.g., temperate or dry) (Raven 1973; Deacon, 1983), with a high endemism rate (Cowling, 1992) and very heterogeneous in space and time in terms of community composition and structure (di Castri, 1973, 1981).

Comparisons of floral and faunal communities between mediterranean regions are not easy because in some cases a high number of taxa with different ages of origin coexist (di Castri & Mooney, 1973). Despite of those difficulties, affinities in faunal communities between the med-regions have been described in numerous studies. Most of them focused on lizards (Sage, 1973; Fuentes, 1976), birds (Cody, 1973; Herrera, 1995) or terrestrial arthropods (di Castri & Mooney, 1973; Majer & Greenslade, 1988; Stamou, 1998), but few are performed in aquatic arthropods, although some suggestions have been made (Gasith & Resh, 1999).

In the mediterranean climate areas, the water high seasonal stress condition implies that organisms present some specific adaptations. Consequently, most of the affinities it can be found between these areas are related to physiological, morphological or behavioral adaptations (e.g. in arthropods —Stamou, 1998) to avoid the severity of drought and its seasonality and interannual variability. In that sense, resilience and resistance are common attributes found in the elements of the mediterranean biota (Grubb & Hopkings, 1986), being the first more frequent (Fox & Fox, 1986). These adaptations give higher probability of permanence to mediterranean communities to the seasonal predictable natural disturbances (Aschmann, 1973; Orshan, 1983).

In addition to this harsh natural conditions, mediterranean climate areas have been exposed since many years ago to human disturbances (Mooney, 1982), although the human impact differs among med-regions because of the different time of human colonization (Aschmann, 1973b; Fox & Fox, 1986). Probably, fire is the main disturbance in these ecosystems (Miller, 1983; Keely, 1986), altering nutrient availability and influencing on speciation (Cowling, 1987) with fire-dependents and resilient plants (Kruger, 1979ac; Fox & Fox, 1986; Keely, 1986). For instance, in the South African fynbos several plants need the fire to reproduce; in Australia some tree are adapted to fire and its frequency and intensity; and even in Chile with a weak fire history, some adaptations to fire are present (Grove & Rackham, 2001).

Trabaud (1981) points out that med-regions are unique to have been affected by human activities for ages, as the introduction of non-native plants and animals, agriculture, cattle, urbanization, salinization... (Conacher & Sala, 1998). Because of the impact of all these activities, med-regions are characterized by lost of natural vegetation, soil salinization, water pollution and high erosion (Conacher & Sala, 1998). These consequences can be more or less important in each region, and topography, lithology or the climate itself can accelerate the erosion and the land degradation (see Conacher & Sala, 1998). Hence, an increase of temperature by climate change could have important consequences in the mediterranean ecosystems, enhancing the water stress in the arid and semiarid areas or prolonging the growth season in the alpine regions (Le Houérou, 1990).

Mediterranean rivers

Rivers influenced by this climatic heterogeneity in temperature and precipitation regimes are considered mediterranean rivers (Gasith & Resh, 1999). Because in the mediterranean climate several microclimates can be distinguished (Nahal, 1981; Daget *et al.*, 1988), we understand that several river typologies can also distinguish in med-regions: from mountain permanent

stream in the most humid areas to ephemeral ones in the most arid ones. In Plates 1 to 5 the main features of med-rivers in the five areas in the world are summarized.

River discharge is related to rainfall patterns (depending on the vegetal cover, temperature, evaporation, relief and soils) (Beckinsale, 1969; Alexander, 1985), and therefore, mediterranean rivers are characterized by yearly variable discharge regimes, with a maximum peak in winter a minimum flow in summer (Bradbury, 1981; Gasith & Resh, 1999). Moreover, an interannual variability is also present carrying out changes in river flow and freshwater communities along time (McElravy *et al.*, 1989; Resh *et al.*, 1990).

Frequently, rainfall in mediterranean rivers is presented as intense storms with a variable frequency, which implies frequent floods in the rainy season, especially in small and steep basins (Paskoff, 1973; Camarasa & Segura, 2001). On the other hand, in the dry season, because of the lack of precipitation and the high evapotranspiration, temporality in small streams can be common (Thrower & Bradbury, 1973; McElravy *et al.*, 1989; Conacher & Conacher, 1998; Gasith & Resh, 1999; del Rosario & Resh, 2000; Camarassa & Segura, 2001), except in cases when discharge is maintained by the influence of ground water (Vidal-Abarca *et al.*, 1996) or by snow-melt when streams are fed by high mountains (Beckinsale, 1969).

As a result of this discharge pattern, aquatic ecosystems are highly subject to biannual hydrologic disturbances, characterized by the alternation of floods and droughts (Molina *et al.*, 1994). This general pattern may be considered as predictable but with a variable frequency and intensity (Gasith & Resh, 1999), being droughts more predictable than floods (Vidal-Abarca, 2001). Permanent rivers may be found in areas with a relative high and predictable rainfall, whereas intermittent or ephemeral ones are located in areas with a low and uncertain rainfall (arid and semiarid zones) and without connection to main aquifers, being completely rainfall dependents (Vidal-Abarca, 1990). Permanency or temporality are functions of precipitation, microclimate patterns and freatic level, although other structural and local factors (e.g., substrate) can be important (see Bonada *et al.*, Chapter 5).

The effect of this variability in discharge over to biological community has been studied by several authors (see Gasith & Resh, 1999). In general, numerous adaptations to droughts (see Williams, 1985) and floods (Statzner *et al.*, 1988; Resh & Solem, 1996) have been found. In early summer, as long as the river is drying up and habitat change, there is a variation in composition and abundance in aquatic biota (Gasith & Resh, 1999). Later, autumn and winter floods connect the isolated reaches in the temporary rivers and provoke spates in temporal

and permanent streams washing out downstream algae and macroinvertebrate communities. After the flood, communities may be reestablished relatively fast (Badri *et al.*, 1987; Vidal-Abarca *et al.*, 1992; Pires *et al.*, 2000). According to the variability of the discharge along the year the rivers and streams can be classified into three groups (Bonada *et al.*, Chapter 5): permanents with running water in summer, intermittents with isolated pools in summer and ephemerals that are totally dried up after few months (even weeks) of the flow cessation.

This variety in characteristics in mediterranean rivers, provided by natural disturbances, is the origin of a high floristic and faunistic diversity (Prat *et al.*, 2000a) and endemism (Gasith & Resh, 1999). However, these ecosystems are very sensitive to a loss of diversity, because the seasonal variability of the mediterranean climate makes the fluvial systems more vulnerable to pollution (Gasith, 1992; Davies *et al.*, 1993; Sabater *et al.*, 1995; Gasith & Resh, 1999). Consequently, Mediterranean rivers are highly affected by human disturbances yielding a very poor ecological status (Prat, 1993; Prat & Munné, 2000). Moreover, in nowhere else in the world the aquatic fauna is declining as rapidly than in mediterranean regions (Moyle & Leidy, 1992) because of the non-native introductions, high population density, limited availability of water and unsatisfactory management.

Johnson (1973) postulated that although similar biota between isolated areas is possible because of a common ancestor, usually the environmental conditions have actuated more or less equally over the evolution of the biota, and so it is not likely that the convergence characteristics are reached by chance. Therefore, because the mediterranean climate shares similar kind of environments, macroinvertebrate communities should also be similar (Gasith & Resh, 1999), as the vegetation (Mooney and Dunn, 1970) or lizard communities are (Fuentes, 1976). Several ecological freshwater studies have been done comparing different biomes, climates or continents (Vinson & Hawkins, 1998) looking for convergences and divergences (Moyle & Herbold, 1987; Lamoroux *et al.*, 2002), but few of them are focused on comparisons between mediterranean rivers (see King *et al.*, 1988), although the numerous local studies performed in these areas (see Gasith & Resh, 1999). Studies about ecological convergences in mediterranean ecosystems are required to determine the applicability to another area of the ecological principles derived from local studies (Kruger *et al.*, 1983).

Because communities have different structure, composition and responses may change at different scales of observation (Kotliar & Wiens, 1990; Tonn *et al.*, 1990; Wiens *et al.*, 1993; Peckarsky *et al.*, 1997). Choosing the appropriate scale of study have been a problem for many stream ecologists (Peckarsky *et al.*, 1997) and thereby, several authors recommend performing

studies at multiple scales of observation to understand patterns and processes of biological communities (Peckarsky *et al.*, 1997; Poff, 1997) and facilitate convergences and divergences between regions (Tonn *et al.*, 1990; Samuels & Drake, 1997). Thus, the aim of this paper is to present convergences and divergences among mediterranean climate rivers over the world at two scales of observation: regional and local (including reach and habitat). The objectives of the study are:

- 1.- To compare faunistic composition of macroinvertebrates at family level between all med-regions, in order to find if differences because of historical reasons may be important for ecological purposes.
- 2.- To study if the effect of temporality and habitat characteristics over the macroinvertebrate community are similar in four med-regions, despite of biogeographical differences.
- 3.- To establish convergences and divergences between the med-regions according to different aspects of the aquatic ecosystems.

METHODOLOGY

The faunistic assemblage in mediterranean rivers

In this Chapter, the assemblage of macroinvertebrates in a region is defined as the total taxa that could be found in any stream of the area at family level at any time (accumulated assemblage). Family level was preferred to simplify comparisons and to avoid data “noise” from genus or species level because of their high biogeographic variability. Moreover, in some areas the genus and species of some families (e.g. Chironomidae) are poorly known or difficult to identify. In some cases, as Oligochaeta and Hydracarina, the order level was used instead of family because taxonomic difficulties. The list of families recorded in each med-region has been obtained using personal data, references and non-published reports of freshwater researchers in each area. Chris Madden from the Australian Water Quality Center and Ricardo Figueroa from the Universidad de la Concepción provided unpublished data from South Australia and Chile, respectively.

Effect of the temporality and habitat on macroinvertebrates

Sites studied

Between 1999 and 2002 the former author made several studies in the mediterranean areas of California, South Africa, SWAustralia and the Mediterranean Basin. In all cases, the sampling period was spring, when the rivers were flowing to enable comparisons between areas.

Table 1. Number of sampling sites in med-regions.

| | Med-Basin | California | South Africa | SW Australia |
|------------------------------------|-----------|------------|--------------|--------------|
| <i>Total reference sites</i> | 42 | 10 | 12 | 9 |
| <i>Total R/L sites (reference)</i> | 8 | 10 | 12 | 9 |
| <i>Permanent reference sites</i> | 32 | 8 | 8 | 6 |
| <i>Temporary reference sites</i> | 10 | 2 | 4 | 3 |

As possible, many types of rivers in headwaters and downstream reaches were sampled, although sampling sites did not cover all the extension of each mediterranean region. Several permanent and temporary reference sites were selected and sampled in all four med-regions. Sites were identified as temporary if the river usually remains intermittent (disconnected pools) or dries up in summer or at least it was dry the summer before the study, whereas sites known to have continuous flow along year were qualified as permanents. Table 1 summarizes the number of sampling sites for each mediterranean sampling area.

Sites in Mediterranean Basin: Spain

Data from spring 1999 was obtained from the GUADALMED project (see Chapter 1). From the 157 sites sampled by the Project, 42 reference localities were used according to the criteria established by Bonada *et al.* (in press b). Sites are distributed along the mediterranean coast of Spain, including the Balearic Islands, and they belong to 11 basins: Besòs Llobregat, Mijares, Turia, Júcar, Segura, Aguas, Almanzora, Guadalfeo, Adra and Pollença (Figure 2). Information about the characteristics of these basins, typology of sites, riparian vegetation and habitat characteristics is found in Robles *et al.* (in press), Bonada *et al.* (in press a), Suárez *et al.* (in press) and Pardo *et al.* (in press). In general terms, sampling sites cover wide types of rivers, as was showed by Bonada *et al.* (in press) from small alpine rivers in Catalonia and Granada to karstic systems in Catalonia, Mallorca or Almería and ramblas in Murcia and Almería. Reference localities with disconnected pools in spring 1999 were non-considered in the analysis. Rainfall accumulated one year before sampling was 507.6 mm in an area near sampling sites (Vallès Oriental, Catalonia).

Sites in California

10 sampling sites in Northern California (Figure 2) were sampled in spring 2002, belonging to 3 of the 5 ecoregions established in California by Bailey (1995): 3 located in the west side of Sierra Nevada in the “Sierran steppe, mixed and coniferous forest”

ecoregion; 4 in “Northern California Coastal redwood forest and steppe” and 3 in “Southern California coastal chaparral woodland, coniferous forest and meadow”. Localities in the Sierra Nevada are reaches with fast flowing waters, in forested basins, medium slopes and substrates with boulders and cobbles. The riparian vegetation is dominated by *Alnus* sp., *Salix* sp. (3 species), *Populus* sp. with some *Pinus lambertiana* and *Pseudotsuga menziesii* from the adjacent coniferous forest. The algae *Nostoc* sp. is abundant and frequently is present in symbiosis with Chironomidae larvae. In coastal ranges, rivers have high slopes with coarse substrate except in the longest rivers (as San Geronimo River) where gravels, sand and bedrock are important. Riparian vegetation is composed by *Quercus lobata*, *Alnus* sp., *Corylus cornuta*, *Sequoia sempervirens* and *Umbellularia californica*. Through the south and near the coast, sampled rivers are short, small and steep. Substrates are similar to the ones in the northern coasts. The riparian vegetation is composed by *Quercus lobata*, *Platanus racemosa*, *Juglans hindsii*, *Populus* sp., *Salix* sp., *Alnus* sp., *Corylus cornuta* and *Umbellularia californica*. Rainfall accumulated one year before sampling was 572.64 mm in an area near sampling sites (Napa valley).

Sites in South Africa

South African survey was performed in spring 2000. Sampling sites were located in three different places (Figure 2): 3 in the Table Mountain ranges, 8 in the area of influence of the Franschhoek and Drakenstein Mountains, and 1 in the low Palmiet close to the sea, in the area called Kogelberg State Forest Reserve. Table Mountain sites have a high slope, with boulders and cobbles dominant, whereas low slopes characterize the rest of sites. In all cases, dominant vegetation is mountain fynbos, although near the river individuals of the riparian shrubs *Metrosideros angustifolia* or *Brabejum stellatifolium* are present. In headwaters, the macrophyte *Isolepes* sp. is abundant with mosses and Palmiet (*Prionium serranum*). Rainfall accumulated one year before sampling was 569.2 mm in an area near sampling sites (Cape Town).

Sites in SW Australia

A total of 9 sites in three catchments in the south of Perth were sampled in spring 1999: Serpentine River, Drakes Brook and Brunswick River (Figure 2). They are located on the Darling Plateau, where the karri forest is present providing a very forested basins by several *Eucalyptus* species and with a shrubby undergrowth. Near the river, individuals of *Melaleuca* sp. are present. Gravels, sand and silt, with bedrock and boulders scarce, dominate the substrate of the rivers. Rainfall accumulated one year before sampling was 774.6 mm in an area near sampling sites (Perth).

Project was to establish a standardized methodology to be used as a Rapid Bioassessment Protocol (RBP). The protocol was initially developed by Prat *et al.* (1997, 1999, 2000b), and has been tested and established later for all sampling sites in GUADALMED Project. Although GUADALMED Protocol was conceived as a bioassessment method, the fine mesh size used (250 μm) and the absence of sampling restrictions comparing with other procedures, allow us the use of this Rapid Bioassessment Protocol (and specially Protocol 2) in macroinvertebrate community studies (Bonada *et al.*, Chapter 2).

In each site, several physical and chemical parameters were measured *in situ* as pH, oxygen (mg/l and %), temperature, conductivity and discharge. Two indexes developed in the GUADALMED Project were applied to check for the applicability of Spanish methodology in other mediterranean areas. The first one is the QBR, an index that to assess riparian vegetation quality (see Munné *et al.*, 1998, 2002; Suárez and Vidal-Abarca, 2000 and Suarez *et al.*, in press). The second one is the IHF designed to characterize habitat diversity (see Pardo *et al.*, in press), a method with some similarities with the RBP's method used in EEUU (see Barbour *et al.*, 1999).

For macroinvertebrates, the GUADALMED methodology consists in collecting samples separately from riffles (R) and lentic (L) habitats with a circular kick net of 250 μm mesh size. Each sample is examined in the field and successive samples in both habitats are taken until no more families are found, to collect a representative sample of the community. Several invertebrates seen in the field but not taken in the sample were also recorded, as the large Heteroptera and Coleoptera. Samples were preserved in alcohol 70% and sorted in the lab, to avoid errors in identifying taxa. Macroinvertebrates were identified at family level (except Oligochaeta and Hydracarina) and a rank of abundances was recorded for each taxa: 1 from 1-3 individuals, 2 from 4-10, 3 from 11-100 and 4 for more than 100 individuals. Thus, data were semiquantitative and all the statistical analysis has been done according to it.

Data Analysis

Macroinvertebrate community assemblage in all med-regions

A Non-metric Multidimensional Scaling (NMDS) was applied to the presence/absence matrix with all taxa in med-regions. This ordination method preserves the distances between objects, plotting dissimilar objects far from the similar ones (Legendre & Legendre, 1998). On the other hand, the NMDS method is a method not based on eigenvalues, and the final axes are arbitrary without enclosing the explained variability. Because of the presence/absence data,

Jaccard coefficient was selected as a binary method to calculate distances between variables. This index is focused in checking similarities between variables, as double 0 are excluded. The statistical program used was the PCORD (McCune & Mefford, 1999).

Differences and similarities between all reference sampling sites in med-regions

Physical, chemical and structural features

Once reference sites were established, a Principal Component Analysis (PCA) was performed to check for differences in environmental variables measured. Prior to analysis, these variables were standardized, tested for autocorrelation with r-Pearson. Skewness values for each variable were also calculated to avoid variables that could bias the analysis (Legendre & Legendre, 1998). PCA is a multivariate ordination analysis based on the Euclidean distance that let to study relationship between objects (sites) and descriptors (variables) in a reduced space. The CANOCO Program vs.4 (ter Braak, 1998) was used to compute the analysis.

Macroinvertebrate's abundances

Common taxa in all sampled regions were used to check for differences between the relative abundance between reference sites in the 4 sampled med-regions. Because in each med-region a different proportion of temporary sites respect permanents were sampled, only permanent sites were used to check similarities and differences in abundances. A non-parametric Kruskal-Wallis test was computed with a relative abundance (in %) data matrix and using sites in med-regions as replicates because its reference condition (Norris, 1995). Previously, data was tested to normality with the Shapiro-Wilk's test (that have a good power properties compared with a wide range of alternative tests), and to homogeneity of variances with the Barlett's test. The STATISTICA Program was used to perform the analysis (Stat Soft, 1999).

Effect of temporality

To test if differences between permanent and temporary sites were higher than between med-regions, a Bray-Curtis cluster with flexible clustering ($\beta=0.25$) was performed using all common taxa. For each med-region, macroinvertebrate relative abundance matrix in permanent and temporary sites was compared using a MRPP analysis (Multi-response Permutation Procedures). This method is a nonparametric method for testing multivariate differences among pre-defined groups (permanent or temporary sites), providing the statistic A and a p-value obtained by permutation (999 runs) as result. Because its non-parametric

condition this method is more appropriated than MANOVA in comparisons of data matrixes that involve species abundances including many zero values.

Several metrics were tested to check for differences between flow conditions: number of taxa, relation EPT/OCH, number of Diptera taxa and number of non-insect taxa. Differences were tested with a Kruskal-Wallis test (after test for normality and homogeneity of variances). Further, an IndVal method (Dufrière & Legendre, 1997) was performed to explain the meaning of the differences found between permanent and temporary sites and to determine the indicator community of each flow condition in med-regions. This method checks the indicator value for each taxon in the defined environmental conditions (permanent and temporary sites). A Monte Carlo permutation test with 9999 permutations was used to test for significance of each indicator value. This analysis has several advantages over the widely used TWINSpan (Hill, 1979) as the possibility to obtain an indicator value for each taxon that is independent of abundances of other species (Dufrière & Legendre, 1997). Only the taxa with more than an indicator value (IV-value) of 25 were kept (Dufrière & Legendre, 1997). In order to find the degree of similarity between two med-regions, the percentage of common taxa in those two regions that have a similar pattern was calculated.

The statistical program PCORD (McCune & Mefford, 1999) was used to compute MRPP, IndVal and Bray-Curtis analysis whereas STATISTICA was employed for the non-parametric tests.

Effect of habitat

Similar analysis performed among riffle and pool habitats were applied to permanent and temporary sites. Thereby, a Bray-Cluster was also performed with common taxa, to test if biogeographical differences were more important than the habitat effect. Further, MRPP test, IndVal method and % of similarity between pair-regions were performed to check for differences among riffles and pools habitats and their indicator community in all mediterranean regions.

RESULTS

Macroinvertebrate community assemblage

A total of 212 different taxa were used to perform the analysis between med-regions. Most of taxa were at family level except Oligochaeta and Hydracarina that were used at a higher taxonomical level. Figure 3 shows the result from NMDS analysis. Macroinvertebrate

community is highly similar between the northern hemisphere med-regions of California and Med-Basin, with a 94% of similarity, while in the southern hemisphere there is an important variability in the macroinvertebrates community. South African community is the nearest to the northern hemisphere, sharing 65% of the taxa, while the Chilean area seems to be the less similar. The two Australian med-regions have 35% of similarity with the South African, California and Med-Basin communities, and 88% between them.

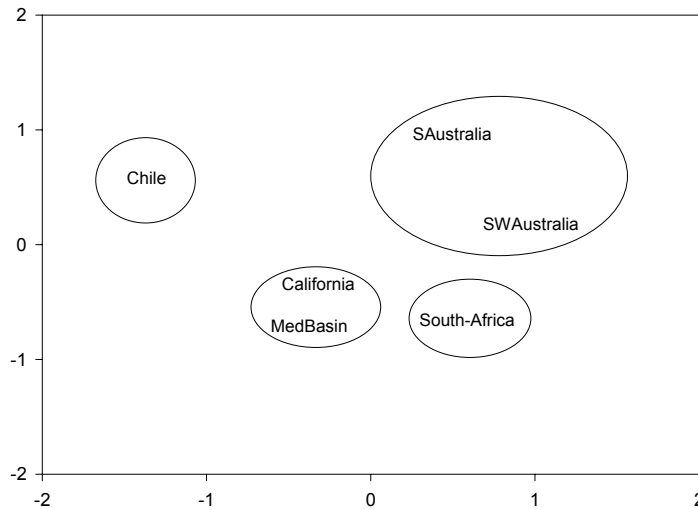


Figure 3. NMDS Plot using Jaccard distance.

The unique and common taxa are variable between regions (Table 2), being South Africa the region with a major number of unique taxa (13 families), followed by South Australia and Chile, both with 11 taxa. California and SWAustralia have few unique taxa, although some coldstenoterm plecopterans, as Peltoperlidae or Pteronarcyidae, are characteristic from North America. The med-region of SWAustralia has a scarce unique community, and only the caddisfly Plectotarsidae seems to be present in this area and absent in SAustralia. On the other hand, South Africa and Chile has important unique taxa from a Gondwanic origin, as Barbarochthonidae, Petrothrincidae and Hydrosalpingidae in South Africa and Austronemouridae or Diamphinoidae in Chile.

Table 2. Exclusive and ubiquitous taxa in the six med-regions.

| Exclusive families | | Ubiquitous families | |
|---------------------------|--------------------|----------------------------|---------------|
| MEdBasin | SAustralia | Aeshnidae | Psychodidae |
| Aphelocheiridae | Conoesucidae | Ancylidae | Simuliidae |
| Beraeidae | Eusiridae | Baetidae | Sphaeriidae |
| Bithynellidae | Hemicorduliidae | Caenidae | Stratiomyidae |
| Ferrissiidae | Nannochoristidae | Ceratopogonidae | Syrphidae |
| Georriidae | Ochteridae | Chironomidae | Tabanidae |
| Limnebiidae | Paracalliopidae | Coenagrionidae | Tipulidae |
| Neritidae | Scatopsidae | Corixidae | |
| Polymitarcidae | Syllidae | Culicidae | |
| Potamanthidae | Talitridae | Dixidae | |
| Prosopistomatidae | Tasimiidae | Dytiscidae | |
| | Telephlebiidae | Elmidae | |
| | | Empididae | |
| California | SWAustralia | Ephydriidae | |
| Ameletidae | Plectrotarsidae | Gerridae | |
| Peltoperlidae | | Gomphidae | |
| Pteronarcyidae | | Gordiidae | |
| Neiridae | | Gyrinidae | |
| | | Haliplidae | |
| Chile | SouthAfrica | Hydracarina | |
| Aeglidae | Barbarochthonidae | Hydrophilidae | |
| Amelotopsidae | Chlorophyidae | Hydropsychidae | |
| Amnicolidae | Dipseudopsidae | Hydroptilidae | |
| Austronemouridae | Hydrosalpingidae | Leptoceridae | |
| Chiliniidae | Munnidae | Leptophlebiidae | |
| Coloburiscidae | Petrothrincidae | Lestidae | |
| Diamphipnoidae | Phreatoicidae | Libellulidae | |
| Eomeropidae | Pisuliidae | Lymnaeidae | |
| Mesobdellidae | Potamonautidae | Notonectidae | |
| Molanidae | Protojaniridae | Oligochaeta | |
| Samastacidae | Spelaeogriphidae | Physidae | |
| | Sternophysingidae | Planorbidae | |
| | Teloganodidae | Polycentropodidae | |

A total of 40 taxa are shared between all med-regions (Table 2), being dipterans the group with more common families. Ephemeroptera as Baetidae, Caenidae and Leptophlebiidae are also found in all med-regions, as well as the caddisflies Hydropsychidae, Hydroptilidae, Polycentropodidae and Leptoceridae, or other Coleoptera, Heteroptera and Odonata. On the other hand, many taxa are shared between several med-regions. For instance, because of their strong similarity, Med-Basin and California have 16 taxa in common (excluding the ubiquitous ones), as the stoneflies Nemouridae, Leuctridae, Capniidae, Chloroperlidae and Perlodidae, or the caddisfly Rhyacophilidae (absent in the southern hemisphere). Other taxa are present in all the med-regions except in one, as Pyralidae only absent in South Africa, Corduliidae or Ecnomidae in California, Glossosomatidae in SWAustralia or Athericidae, Dugesidae and Hydraenidae in SAustralia. Moreover, this last continent lacks of families abundant in other regions as Blephariceridae, Dryopidae or Sericostomatidae (see Annex 1).

Crustaceans are the group more convergent between regions in southern hemisphere, with some variability. From the common taxa between SAustralia and SWAustralia, 5 are crustaceans (Ceinidae, Hymenosomatidae, Oniscidae, Parastacidae and Perthiidae), at the same time that Janiridae and Paramelitidae are shared with South Africa. This taxonomical group has numerous exclusive families in Southern Hemisphere (4 in SAustralia, 5 in South Africa and 2 in Chile). In northern hemisphere, there are few crustacean families, and only the Astacidae seems to be exclusive in Med-Basin and California. Other similarities in the crustacean taxa are between some taxa that has been introduced in several med-regions as Cambaridae from North America, introduced in Med-Basin and South Africa, or Grapsidae introduced in California and Med-Basin regions.

Another taxonomical group shared between med-regions in southern hemisphere is Odonata, with South Africa and SAustralia having 2 families in common (Chorolestidae and Protoneuridae), 1 between Chile and SWAustralia (Petaluridae), and 2 between both Australian med-regions (Synthemidae and Megapodagrionidae). Although there are a high similarity between Odonata and Crustacea in southern hemisphere, few convergences exist in other groups (excluding the ubiquitous taxa), as Ephemeroptera, with only the Onicogastridae shared by Chile and SAustralia. Plecoptera shows a typical distribution around med-regions, with more families in northern hemisphere (until 8) than in the South one: 4 in SAustralia, 7 in Chile, 1 in SWAustralia and 1 in South Africa. Notonemouridae is exclusive from South Africa, Chile and SAustralia, and absent in SWAustralia. In this last region, the Gripopterygidae are present and only shared with SAustralia and Chile. On the other hand,

Chile and SAustralia have 2 common stoneflies (Austroperlidae and Eustheniidae) absent in other med-regions.

Many connections are found between north and southern hemisphere, as Noteridae or Platycnemidae in Med-Basin and South Africa, or Corylidae in South Africa, Chile and California. A relationship between northern hemisphere and South Africa or Chile is noticed, with some coldstenoterm families in fast flowing waters as Heptageniidae, Lepidostomatidae or Goeridae only in South Africa, California and Med-Basin; or as for example Perlidae, Psychomyiidae and Limnephilidae in the northern hemisphere and Chile. Other linkages between both Hemispheres are recent because the human introductions of Mollusca (Physidae in Australia, Hydrobiidae in Med-Basin, Corbiculiidae in California) or Crustacea (Cambaridae in Med-Basin and Grapsidae in California and Med-Basin).

When the list of taxa is analyzed for each med-region according to several multimetric indexes (Figure 4a-h), a differential composition among med-regions is found (Figure 4d-h). Communities from northern hemisphere have higher richness in Ephemeroptera, Plecoptera and Trichoptera, while in the southern hemisphere Coleoptera, Heteroptera, Diptera and non-Insect are more abundant. Taxa richness (as number of taxa) is slightly higher in Med-Basin (125), California (119), South Africa (104) and SAustralia (120), compare with Chile (92) and SWAustralia (98). However, even though this similarity in richness, taxonomical composition between med-regions is different (Figure 4b-h). Number of EPT appears to be high in Med-Basin, California, Chile and SAustralia (Figure 4b), because a major number of Plecoptera (Figure 4f), while is low on South Africa and SWAustralia with only one stonefly family (Notonemouridae and Gripopterygidae, respectively) (Annex 1). On the other hand, the low value of EPT/OCH in Australia would indicate that although having a high EPT value, the OCH are more important than in other med-regions (Figure 4h). In general, in southern hemisphere the percentage of non-insect taxa is higher, because of the presence of many crustacean families (Figure 4d). This phenomenon is more important in Australia and South Africa than in Chile, because in this last region the community is mainly composed by Ephemeroptera, Plecoptera and Trichoptera, being more similar to the northern hemisphere one at order level (Figure 4e-g).

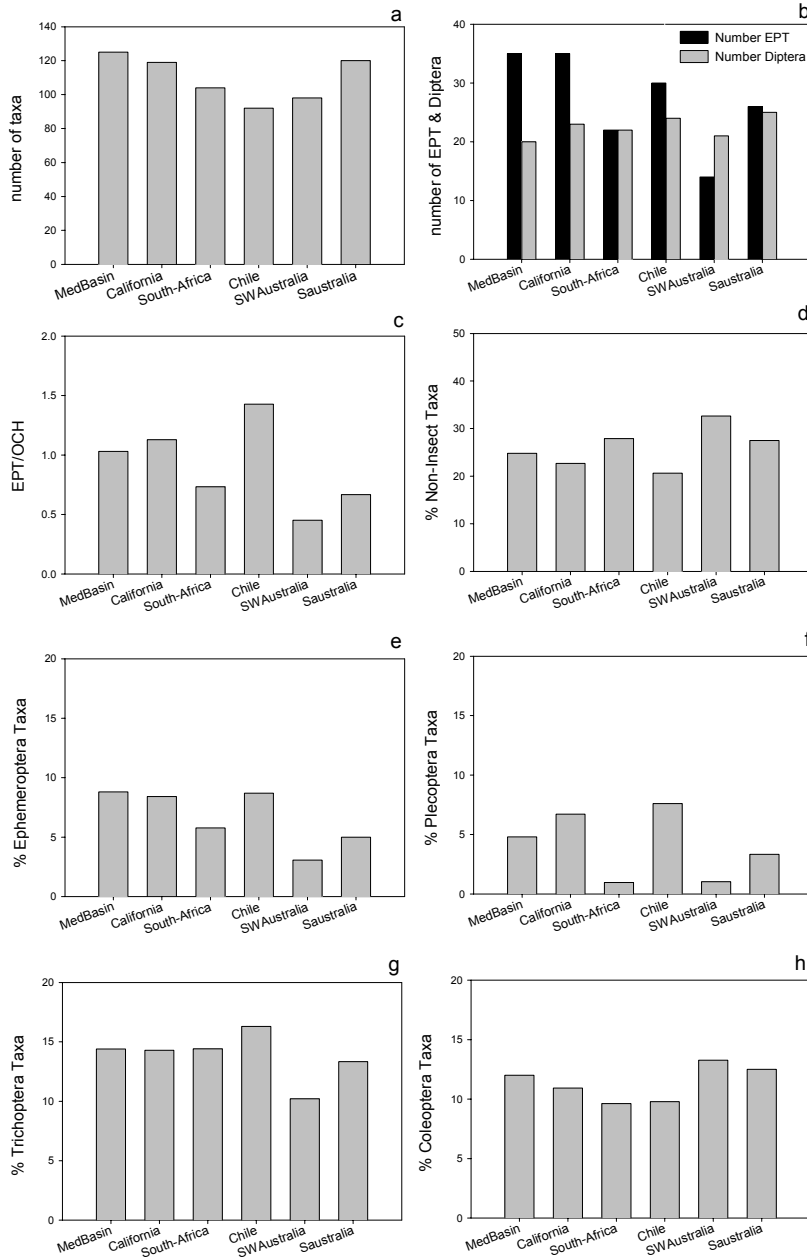


Figure 4. Multimetric indexes between mediterranean regions.

Differences between all sampling sites in med-regions

Physical, chemical and structural differences

Pearson correlations between environmental variables, presented significant correlation between pH-Temperature ($p=0.001$), Temperature-Conductivity ($p=0.034$), Temperature-Discharge ($p=0.03$), Temperature-IHF ($p=0.008$) and QBR-Conductivity ($p=0.002$) (Table 3). Because the correlation coefficients were low ($r<0.4$) all variables were used in further analysis. Skewness values associated to each variable showed that Conductivity ($s=7.449$) and Discharge ($s=7.569$) had a high data asymmetry and consequently were deleted from the PCA analysis (Table 3). Only QBR, pH, temperature and IHF were used to avoid a bias in the results.

Table 3. Pearson correlations and skewness values for all measured environmental features. In bold, significant correlations ($p<0.05$) and high skewness values. Temp: temperature; Cond: conductivity; Dis: discharge.

| | | pH | Temp | Cond | QBR | IHF | Dis | Skewness |
|-------------|------------------|---------------|---------------|---------------|---------------|---------------|--------------|-----------------|
| pH | <i>r-Pearson</i> | | -0.379 | 0.137 | -0.226 | 0.183 | -0.133 | |
| | <i>p-value</i> | | 0.001 | 0.245 | 0.053 | 0.118 | 0.260 | -1.310 |
| Temp | <i>r-Pearson</i> | -0.379 | | 0.246 | -0.067 | -0.305 | 0.252 | |
| | <i>p-value</i> | 0.001 | | 0.034 | 0.571 | 0.008 | 0.030 | 0.004 |
| Cond | <i>r-Pearson</i> | 0.137 | 0.246 | | -0.359 | -0.146 | -0.069 | |
| | <i>p-value</i> | 0.245 | 0.034 | | 0.002 | 0.214 | 0.561 | 7.449 |
| QBR | <i>r-Pearson</i> | -0.226 | -0.067 | -0.359 | | 0.101 | 0.122 | |
| | <i>p-value</i> | 0.053 | 0.571 | 0.002 | | 0.391 | 0.299 | -1.854 |
| IHF | <i>r-Pearson</i> | 0.183 | -0.305 | -0.146 | 0.101 | | -0.114 | |
| | <i>p-value</i> | 0.118 | 0.008 | 0.214 | 0.391 | | 0.335 | -0.249 |
| Dis | <i>r-Pearson</i> | -0.133 | 0.252 | -0.069 | 0.122 | -0.114 | | |
| | <i>p-value</i> | 0.260 | 0.030 | 0.561 | 0.299 | 0.335 | | 7.569 |

The first two PCA axis from the analysis made with selected variables explain 68.74% of total variability of the physical-chemical data and results are plotted in Figure 5. First axis is highly correlated positively with pH ($r=0.5891$) and IHF ($r=0.4995$) and negatively with temperature ($r=-0.6315$), whereas QBR is located positively and near the second axis ($r=0.8313$). Thereby, X₂-axis would be related to a good riparian status, and the X₁-axis with abiotic factors as pH, temperature and habitat diversity availability. A clear segregation of sites is noticed between med-regions, and different physical-chemical conditions can be associated with each one.

Reference sites in Med-Basin have a higher pH and IHF compare with SWAustralia and South Africa, but a lower riparian quality. Californian sites are located near Med-Basin with more neutral pH but variable conditions of riparian vegetation and habitat diversity. Finally, samples from South Africa and SWAustralia are associated with low pH, high temperature, good riparian quality and medium to lower habitat diversity.

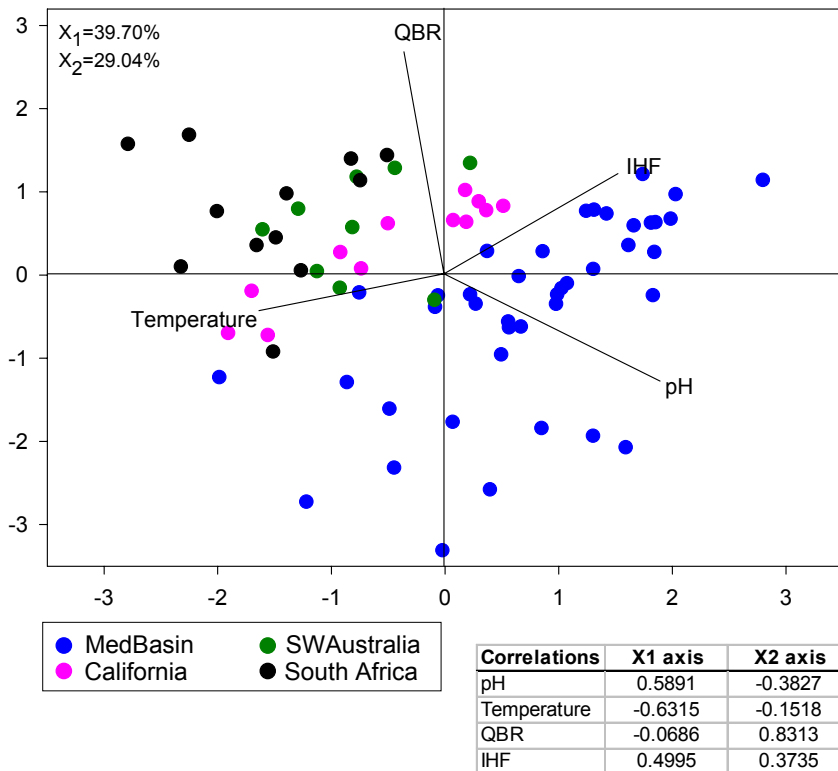


Figure 5. PCA plot with environmental variables in reference sites.

Relative abundance of common taxa between sampled med-regions

In Table 4, results of the non-parametric ANOVA (model Kruskal-Wallis by ranks) indicate that in permanent sites, the relative abundance of taxa is variable between med-regions, with a 51% of common taxa showing significant differences in abundance between regions (p-value<0.05 in Table 4). The rest of taxa have a similar abundance between regions, including

the abundants Caenidae, Hydropsychidae, Hydroptilidae, Ostracoda, Corixidae, several Odonata and several infrequent taxa (Thyaridae, Sphaeriidae, Sciomyzidae, Dolichopodidae...).

Table 4. Kruskal-Wallis non-parametric tests with relative abundances of common taxa in MedBasin, California, South Africa and SWAustralia permanent sites. * $p < 0.05$ and ** $p < 0.001$.

| | Chi-squared (K-W test) | p-value | |
|-----------------|------------------------|---------|----|
| Aeshnidae | 12.46 | 0.006 | ** |
| Ancyliidae | 8.4 | 0.038 | * |
| Anthomyidae | 1.58 | 0.662 | |
| Athericidae | 11.4 | 0.009 | ** |
| Atyidae | 8.15 | 0.043 | * |
| Baetidae | 11.79 | 0.008 | ** |
| Caenidae | 3.5 | 0.32 | |
| Ceratopogonidae | 14.5 | 0.002 | ** |
| Chironomidae | 16.12 | 0.001 | ** |
| Coenagrionidae | 8.43 | 0.037 | * |
| Corixidae | 1.05 | 0.787 | |
| Culicidae | 0.7 | 0.873 | |
| Dixidae | 12.25 | 0.006 | ** |
| Dolichopodidae | 2.18 | 0.535 | |
| Dugesidae | 4.16 | 0.244 | |
| Dytiscidae | 6.79 | 0.078 | |
| Elmidae | 11.12 | 0.011 | * |
| Empididae | 15.79 | 0.001 | ** |
| Ephidridae | 0 | 1 | |
| Gerridae | 17.36 | 0 | ** |
| Gomphidae | 4.46 | 0.215 | |
| Gyrinidae | 4.04 | 0.256 | |
| Haliplidae | 6.22 | 0.101 | |
| Helodidae | 14.16 | 0.002 | ** |
| Hydracarina | 11.44 | 0.009 | ** |
| Hydraenidae | 20.19 | 0 | ** |
| Hydrobiidae | 9.25 | 0.026 | * |
| Hydrometridae | 2.18 | 0.535 | |
| Hydrophilidae | 2.02 | 0.567 | |
| Hydropsychidae | 1.66 | 0.644 | |
| Hydroptilidae | 0.62 | 0.89 | |
| Leptoceridae | 23.62 | 0 | ** |

| | | | |
|-------------------|-------|-------|----|
| Leptophlebiidae | 17.11 | 0 | ** |
| Lestidae | 2.3 | 0.511 | |
| Libellulidae | 1.6 | 0.658 | |
| Lymnaeidae | 7.42 | 0.059 | |
| Naucoridae | 2.18 | 0.535 | |
| Nepidae | 6.4 | 0.091 | |
| Notonectidae | 9.49 | 0.023 | * |
| Oligochaeta | 15.16 | 0.001 | ** |
| Ostracoda | 6 | 0.111 | |
| Philopotamidae | 11.58 | 0.009 | ** |
| Physidae | 10.41 | 0.015 | * |
| Planorbidae | 5.71 | 0.126 | |
| Pleidae | 2.18 | 0.535 | |
| Polycentropodidae | 8.43 | 0.037 | * |
| Psychodidae | 1.64 | 0.648 | |
| Sciomyzidae | 0 | 1 | |
| Simuliidae | 19 | 0 | ** |
| Sphaeriidae | 5.96 | 0.113 | |
| Stratiomyidae | 9.25 | 0.026 | * |
| Tabanidae | 8.43 | 0.037 | * |
| Thyaridae | 1.56 | 0.459 | |
| Tipulidae | 13.79 | 0.003 | ** |
| Veliidae | 11.89 | 0.007 | ** |

Figure 6 plot the average of relative abundance patterns for all significant taxa ($p < 0.005$) between sampled med-regions permanent sites. Oligochaeta, Baetidae, Chironomidae and Simuliidae are very abundant in all med-regions although several differences and similarities are present between them. For most groups of taxa, greater differences in the abundance pattern are shown in the interhemispheric comparisons, whereas the intrahemispheric show higher similarities (Figure 6). The sampled area in Med-Basin is characterized by a higher number of Mollusca, Coleoptera, Chironomidae, Notonectidae and Baetidae, but a lower Leptophlebiidae, Hydracarina and Simuliidae compared with California (Figure 6). Fewer similarities in relative abundance are shown between South Africa and SWAustralia with higher numbers of Leptoceridae in contrast to MedBasin and California.

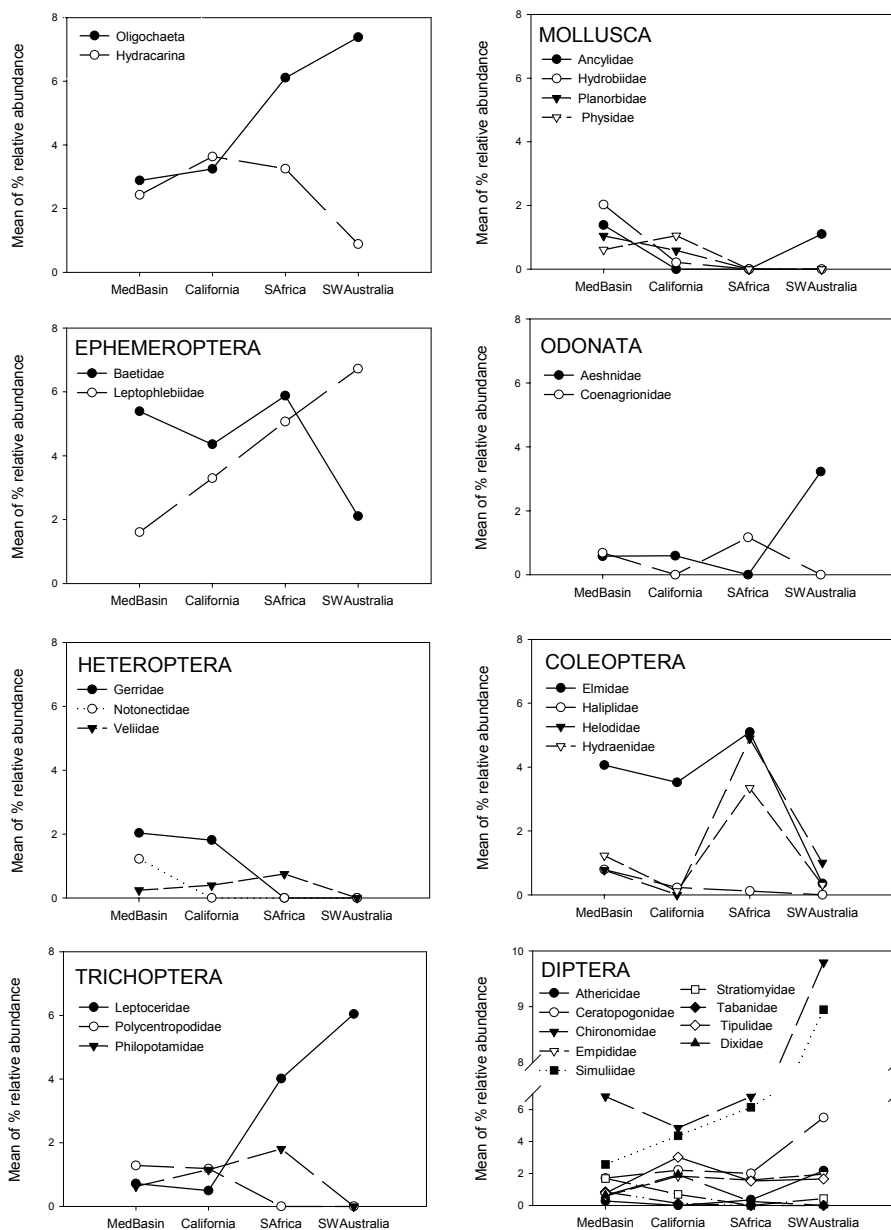


Figure 6. Mean of the abundances relatives for permanent sampled sites in MedBasin, California, South Africa and SWAustralia. Only the significant taxa are plotted ($p < 0.005$).

However, southern hemisphere med-regions present lower abundances of Mollusca, Heteroptera, Polycentropodidae and some Diptera compared with northern hemisphere. South Africa is characterized by a high relative abundance of Elmidae, Helodidae and Hydraenidae compared with the other med-regions, but a low abundance in Mollusca. In SWAustralia, Oligochaeta, Aeshnidae, Leptophlebiidae, Chironomidae, Simuliidae and Ceratopogonidae are more abundant than other med-regions. Consequently, other taxa are less frequent as Coleoptera, Heteroptera, Hydracarina, Polycentropodidae, Philopotamidae and Baetidae (Figure 6).

Effect of temporality

Although similarities and differences between some med-regions were shown by common taxa abundances for permanent sites, responses of communities to temporality may also differ between areas. Results from Bray-Curtis Cluster made with common taxa in all med-regions (Figure 7), indicate differences between regions are higher than between permanent and temporary sites. Each region is grouped together, and in each cluster permanent and temporary sites are included. MedBasin is the first region to be clustered, followed by SWAustralia. California and South Africa appear closer, indicating a similar response of communities to temporality. However, when each region is analysed independent of the other, and all taxa (common and exclusive) are analysed, differences in macroinvertebrate community between permanent and temporary sites ($p < 0.01$) are found in all regions except for SWAustralia ($p > 0.05$), as is show in Table 5.

Table 5. MRPP results between different categories and regions. * $p < 0.05$ and ** $p < 0.001$.

| | PERMANENT vs TEMPORAL | | RIFFLES vs POOLS | |
|-------------|------------------------------|------------|-------------------------|---------|
| | A | p-value | A | p-value |
| Med-Basin | 0.036 | 0.000014** | 0.03 | 0.017* |
| California | 0.0664 | 0.0084** | 0.1182 | 0** |
| SouthAfrica | 0.0666 | 0.0094** | 0.0839 | 0** |
| SWAustralia | 0.011 | 0.3192 | 0.0789 | 0** |

The macroinvertebrate assemblage in SWAustralia and South Africa has a number of taxa, dipterans, EPT/OCH similar between permanent and temporary sites (Figure 8 and Table 6).

For the rest of med-regions number of taxa and % of non-insect taxa is similar between permanent and temporary sites, but there are differences in the EPT/OCH ratio and the number of dipterans. MedBasin has a significantly higher EPT/OCH in permanent sites than temporary, whereas in California, even though this ratio is also higher in permanent localities, it is not significant. Number of dipterans is significantly lower in permanent sites from California, but similar to temporary in the rest of sampling areas.

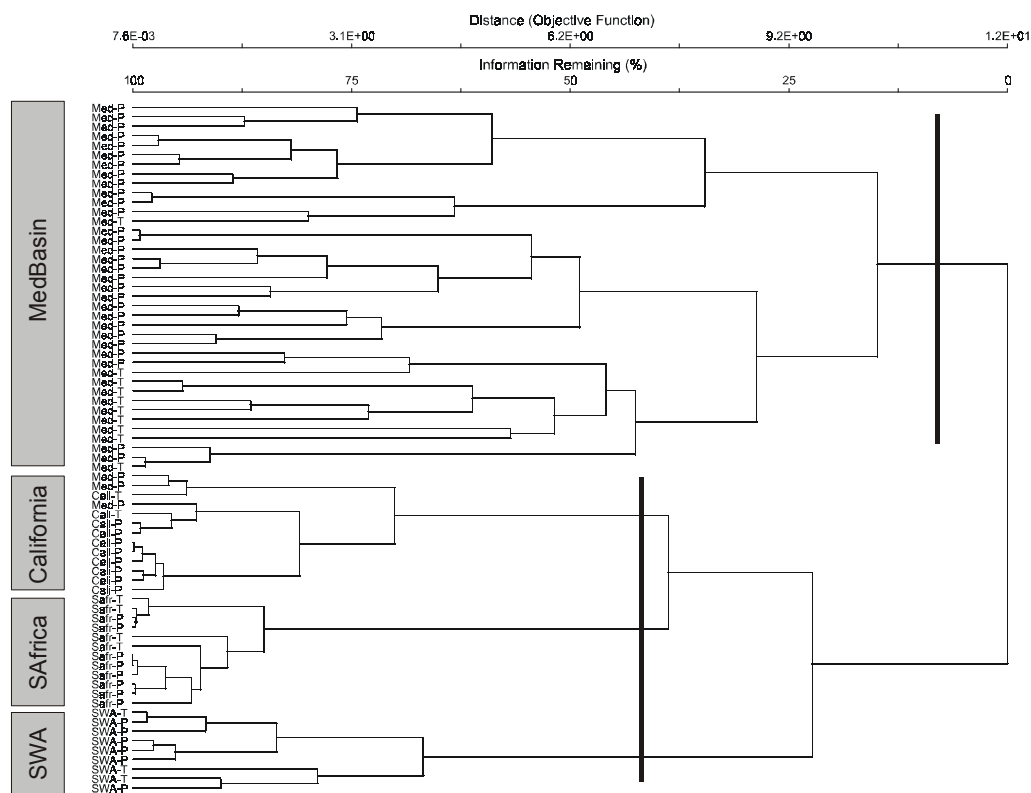


Figure 7. Bray-Curtis cluster with common matrix and permanent and temporary reference sites.

When the analysis are performed comparing all regions separately in permanent and temporary sites (Table 6), only number of taxa and EPT/OCH ratio in permanent sites are significantly different between med-regions. For both metrics, California has higher values in permanent sites compared with the rest of med-regions. No differences exist between regions for all metrics in temporary sites, although box-plot graphs indicate lower higher number of taxa and dipterans in California but a low % of non-insect taxa respect the other regions.

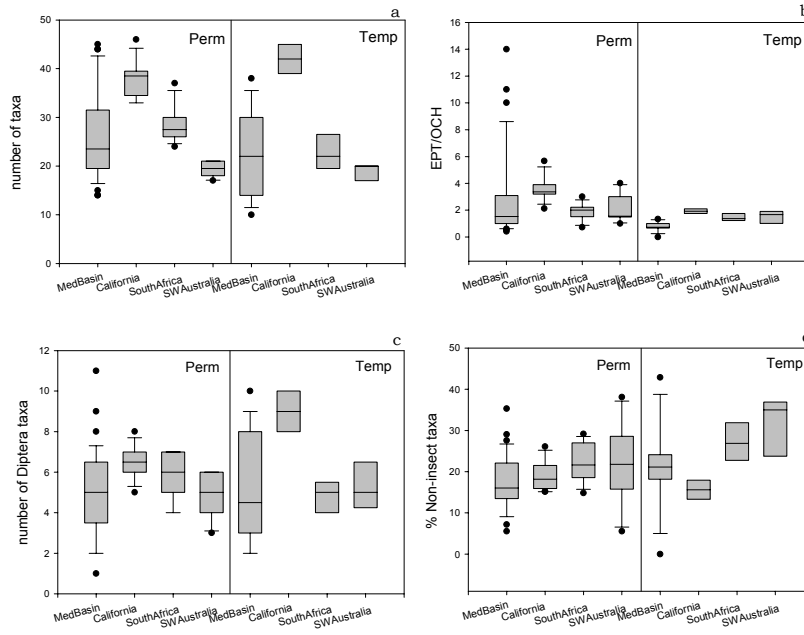


Figure 8. Box-plot between permanent and temporary reference sites.

Table 6. Kruskal-Wallis non-parametric tests between med-regions and temporality. PERM=permanent sites and TEMP=temporary sites. * $p < 0.05$ and ** $p < 0.001$.

| | | Taxa | EPT/OCH | Dipterans | %Non-insect |
|--------------------|-----------------------------|-----------------|----------------|------------------|--------------------|
| PERM among regions | <i>Chi-squared K-W test</i> | 15.52 | 9.7916 | 4.7769 | 3.666 |
| | <i>p-value</i> | 0.0014** | 0.0204* | 0.1889 | 0.2998 |
| TEMP among regions | <i>Chi-squared K-W test</i> | 4.96 | 6.899 | 0.3886 | 3.6909 |
| | <i>p-value</i> | 0.1747 | 0.0752 | 0.274 | 0.2968 |
| MedBasin | <i>Chi-squared K-W test</i> | 0 | 4.72 | 0.364 | 2.1 |
| | <i>p-value</i> | 1 | 0.0297* | 0.5459 | 0.1473 |
| California | <i>Chi-squared K-W test</i> | 0.4761 | 2.5 | 5.833 | 1.666 |
| | <i>p-value</i> | 0.4902 | 0.1139 | 0.0157* | 0.1967 |
| South Africa | <i>Chi-squared K-W test</i> | 1.5 | 0.6857 | 2 | 1.5 |
| | <i>p-value</i> | 0.2207 | 0.4076 | 0.1573 | 0.2207 |
| SW Australia | <i>Chi-squared K-W test</i> | 1.2857 | 0.9 | 0 | 0.9 |
| | <i>p-value</i> | 0.2568 | 0.3428 | 1 | 0.3428 |

The values of IV-values for each taxon obtained with IndVal analysis are shown in Table 7. Firstly, it is interesting to note, that although no significant differences are found between permanent and temporary sites in SWAustralia (Table 5), several taxa appear to have a high IV-value. Overall, the general pattern observed indicates that in springtime, permanent community present more taxa characteristic from riffles, whereas temporary sites have a pool of more tolerant taxa. Thereby, EPT taxa are more common in permanent localities and OCH in temporary ones. Several convergences are observed among regions, with MedBasin and California sharing taxa as Rhyacophilidae, Perlidae and Ephemerellidae in permanent sites. Other plecopterans as Nemouridae have a high IV-value in temporary sites in MedBasin, but in permanent localities in California. The SWAustralia stonefly Gripopterygidae and Notonemouridae in South Africa have a high IV-value in temporary sites. Ephemeroptera are also more common in permanent sites than in temporary ones with Ephemerellidae in MedBasin and California and Teloganodidae in South Africa, or Heptageniidae in MedBasin and South Africa. On the other hand, Leptophlebiidae only is a family associated to permanent localities in SWAustralia whereas is more typical from temporary sites in MedBasin and South Africa. Some caddisflies are also more abundant in permanent than in temporary sites as the reophilic families Hydropsychidae (MedBasin, South Africa and SWAustralia) or Rhyacophilidae (MedBasin and California) or the close family Hydrobiosidae (SWAustralia) or its equivalent in South Africa (the predator Corydalidae). Hydroptilidae and the mayfly Caenidae are permanent families in MedBasin and SWAustralia but associated to temporary habitats in California. Other caddis exclusive form South Africa have found in permanent sites as the lotic families Barbarothonidae and Petrothrincidae, whereas Pisuliidae is indicator of temporary localities. Leptoceridae, a very abundant caddisfly in southern hemisphere, is characteristic from permanent sites there, but from temporary reaches in California. Similar pattern is observed in Hydropsychidae, Elmidae and Heptageniidae, characteristic from permanent sites in MedBasin and South Africa but from more temporary sites in California.

Table 7. IndVal results between permanent and temporary sites for each med-region. Line separates taxa significant at $p < 0.05$ from not significant. Non-significant taxa are from high indicator values (IV) to low. Only taxa with IV higher than 25 are presented (Düfrené & Legendre, 1997).

| MEDBASIN | | | | | | CALIFORNIA | | | | | |
|-----------------|----|---------|-----------------|------|-----------------|-------------------|-------|-------------------|------------------|-------|---------|
| Permanent | IV | p-value | Temporary | IV | p-value | Permanent | IV | p-value | Temporary | IV | p-value |
| Elmidae | 65 | 0 | Hydrometridae | 72.5 | 0 | Ceratopogonidae | 81 | 0.029 | Culicidae | 100 | 0.029 |
| Baetidae | 69 | 0 | Veliidae | 41.4 | 0 | Limnephilidae | 100 | 0.029 | Stratiomyidae | 95.2 | 0.053 |
| Hydropsychidae | 70 | 0 | Hydrophilidae | 38.1 | 0.03 | Perlidae | 85.7 | 0.029 | Caenidae | 88.9 | 0.073 |
| Heptageniidae | 56 | 0.02 | Planorbidae | 33.1 | 0.04 | Rhyacophilidae | 85.2 | 0.029 | Corixidae | 85.7 | 0.074 |
| Gomphidae | 44 | 0.02 | Culicidae | 28.2 | 0.04 | Nemouridae | 85.7 | 0.055 | Brachycentridae | 80 | 0.078 |
| Perlidae | 49 | 0.02 | Dytiscidae | 54.1 | 0.05 | Ephemerellidae | 84.6 | 0.058 | Physidae | 76.2 | 0.108 |
| Calopterygidae | 38 | 0.04 | Chironomidae | 52.9 | 0.26 | Nematoda | 75 | 0.138 | Hydroptilidae | 75.7 | 0.053 |
| Hydroptilidae | 48 | 0.05 | Ostracoda | 42.2 | 0.09 | Sialidae | 75 | 0.164 | Philopotamidae | 63.2 | 0.202 |
| Simuliidae | 49 | 0.07 | Oligochaeta | 41.8 | 0.43 | Tipulidae | 64.7 | 0.071 | Oligochaeta | 58.3 | 0.35 |
| Rhyacophilidae | 48 | 0.07 | Gerridae | 37.8 | 0.21 | Empididae | 61.9 | 0.286 | Dixidae | 57.1 | 0.589 |
| Ephemerellidae | 39 | 0.15 | Stratiomyidae | 34.7 | 0.29 | Dytiscidae | 52.5 | 0.629 | Chloroperlidae | 57.1 | 0.618 |
| Caenidae | 39 | 0.18 | Leptophlebiidae | 33.8 | 0.12 | Calamoceratidae | 50 | 0.453 | Ostracoda | 55.8 | 0.683 |
| Hydracarina | 38 | 0.54 | Notonectidae | 33.2 | 0.17 | Sphaeridae | 50 | 0.457 | Hydracarina | 54.9 | 0.352 |
| Hydrobiidae | 35 | 0.11 | Ceratopogonidae | 32 | 0.79 | Peltoperlidae | 50 | 0.475 | Lepidostomatidae | 54.1 | 0.58 |
| Gammaridae | 34 | 0.13 | Hydraenidae | 31.4 | 0.23 | Asellidae | 37.5 | 0.55 | Hydropsychidae | 52.2 | 1 |
| Helodidae | 31 | 0.09 | Lymnaeidae | 30.5 | 0.18 | Cordulegasteridae | 37.5 | 0.681 | Heptageniidae | 51.3 | 0.933 |
| Limnephilidae | 30 | 0.97 | Nemouridae | 29.9 | 0.45 | Perlodidae | 37.5 | 0.705 | Elmidae | 51.1 | 1 |
| Brachycentridae | 28 | 0.13 | | | Odontoceridae | 37.5 | 0.709 | Belostomatidae | 50 | 0.2 | |
| Ephemeridae | 25 | 0.16 | | | Psephenidae | 37.5 | 0.912 | Ephydriidae | 50 | 0.2 | |
| | | | | | Glossosomatidae | 28.4 | 1 | Haliplidae | 50 | 0.2 | |
| | | | | | Psychodidae | 27.8 | 1 | Sciomyzidae | 50 | 0.2 | |
| | | | | | Corydalidae | 25 | 1 | Coenagrionidae | 50 | 0.212 | |
| | | | | | | | | Hydraenidae | 50 | 0.212 | |
| | | | | | | | | Naucoridae | 50 | 0.212 | |
| | | | | | | | | Tabanidae | 50 | 0.212 | |
| | | | | | | | | Polycentropodidae | 50 | 0.465 | |
| | | | | | | | | Chironomidae | 50 | 1 | |
| | | | | | | | | Gerridae | 50 | 1 | |
| | | | | | | | | Psychomyiidae | 44.4 | 0.2 | |
| | | | | | | | | Hydrophilidae | 40 | 0.222 | |
| | | | | | | | | Tricorytidae | 40 | 0.238 | |
| | | | | | | | | Lestidae | 40 | 0.377 | |
| | | | | | | | | Gomphidae | 36.4 | 0.601 | |
| | | | | | | | | Planorbidae | 36.4 | 0.602 | |
| | | | | | | | | Dugesidae | 35.3 | 0.593 | |
| | | | | | | | | Sericostomatidae | 35.3 | 0.729 | |
| | | | | | | | | Siphonuridae | 33.3 | 0.381 | |
| | | | | | | | | Pteronarcyidae | 33.3 | 0.381 | |
| | | | | | | | | Leptoceridae | 33.3 | 1 | |
| | | | | | | | | Oribatidae | 28.6 | 1 | |
| | | | | | | | | Uenoidae | 28.6 | 1 | |
| | | | | | | | | Aeshnidae | 28.6 | 1 | |
| | | | | | | | | Cambaridae | 25 | 1 | |
| | | | | | | | | Helicopsychidae | 25 | 1 | |

| SOUTH AFRICA | | | | | | SWAUSTRALIA | | | | | |
|------------------|----|---------|-----------------|------|---------|-----------------|------|---------|----------------|------|---------|
| Permanent | IV | p-value | Temporary | IV | p-value | Permanent | IV | p-value | Temporary | IV | p-value |
| Barbarocthonidae | 88 | 0.01 | Paramelitidae | 86.7 | 0.01 | Hydropsychidae | 68.4 | 0.13 | Griopterygidae | 61.5 | 0.25 |
| Leptoceridae | 71 | 0.02 | Hydracarina | 56.2 | 0.46 | Baetidae | 66.7 | 0.172 | Hydracarina | 53.3 | 0.235 |
| Hydropsychidae | 67 | 0.08 | Nematoda | 51.9 | 0.81 | Leptophlebiidae | 61.5 | 0.23 | Oligochaeta | 51.6 | 1 |
| Blepharoceridae | 66 | 0.11 | Oligochaeta | 51.7 | 0.58 | Simuliidae | 55.6 | 0.358 | Chironomidae | 50 | 1 |
| Petrothrincidae | 63 | 0.12 | Leptophlebiidae | 51.1 | 1 | Aeshnidae | 55.6 | 0.48 | Perthiidae | 44.4 | 0.393 |
| Elmidae | 57 | 0.06 | Chironomidae | 50 | 1 | Ceratopogonidae | 54.5 | 0.635 | Psychodidae | 44.4 | 0.48 |
| Teloganodidae | 57 | 0.18 | Notonemouridae | 47.8 | 1 | Leptoceridae | 52 | 1 | Dytiscidae | 44.4 | 0.523 |
| Baetidae | 56 | 0.17 | Helodidae | 47.8 | 1 | Corduliidae | 50 | 0.371 | Ostracoda | 44.4 | 0.643 |
| Hydraenidae | 56 | 0.56 | Dytiscidae | 42.9 | 0.17 | Athericidae | 50 | 0.387 | Tipulidae | 38.1 | 0.519 |
| Simuliidae | 54 | 0.07 | Ostracoda | 37.5 | 1 | Hydroptilidae | 50 | 0.396 | Coenagrionidae | 33.3 | 0.305 |
| Glossosomatidae | 53 | 0.31 | Dugesidae | 30.8 | 0.85 | Hydrobiosidae | 50 | 0.412 | Gyrinidae | 33.3 | 0.325 |
| Tipulidae | 52 | 0.37 | Hirudinidae | 25 | 0.32 | Empididae | 47.6 | 0.461 | Stratiomyidae | 33.3 | 0.325 |
| Coenagrionidae | 50 | 0.19 | Psiliidae | 25 | 0.34 | Parastacidae | 44.4 | 0.543 | Nematoda | 29.6 | 1 |

Temporary sites are characterized by high abundance of OCH taxa, together with some other taxa as Mollusca, Oligochaeta and Crustacea. Dytiscidae is a temporary family in MedBasin, South Africa and SWAustralia but not in California, whereas Haliplidae only have a high IV-value in temporary sites of California. On the other hand, Gyrinidae is an indicator family only of SWAustralia and MedBasin. Heteroptera are exclusively temporary families, but Odonata have permanent and temporary taxa. Lestidae, Gomphidae and Coenagrionidae are temporary families in California. Coenagrionidae also is a temporary family in SWAustralia but a permanent in South Africa. Similar divergences are observed with Gomphidae, a significant Odonata family found in permanent sites in MedBasin but with a high IV-value in temporary sites of California. Crustaceans and Mollusca appear to be more indicator taxa from temporary than permanent sites, with Planorbidae present in MedBasin and California, or Lymnaeidae common in MedBasin and Physidae in California. Other taxa are present in temporary sites in all med-regions, as Ostracoda or Oligochaeta.

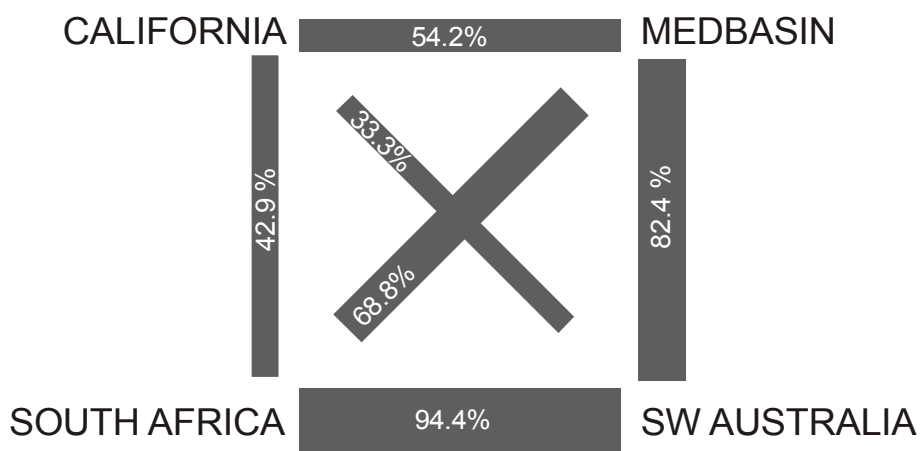


Figure 9. Percentages of similarity between med-regions considering common abundant and representative (IV-value) taxa for each pair of med-regions, in permanent and temporary sites.

Figure 9 displays percentages of similarities in macroinvertebrate responses under permanency and temporality between each pair of med-regions. These similarity values were obtained using common taxa with high IV-values (very abundant and representative) present between pair of med-regions. When comparing two med-regions if a common family was representative from different conditions (permanent or temporary) in one region respect to the

others, it was recorded as a dissimilarity, whereas when a family display a similar affinity in both regions it was recorded as a similarity. Thereby, and according to Figure 9, the highest percentage of similarity is shown between South Africa and SWAustralia, indicating that common taxa with high indicator values display a similar pattern in both regions. Consequently, 94.4% of the common and abundant taxa between South Africa and SWAustralia present a similar response to the permanency and temporality. On the other hand, MedBasin and SWAustralia also show a high similarity, compared with the rest of paired-comparisons. In fact, California and MedBasin, even though sharing more families with a high IV-value than the other regions only 54.2% of the taxa display a similar segregation in permanent and temporary sites.

Habitat effects

In Figure 10 the cluster using all common taxa in sampled med-regions is presented. Differences between regions are higher than between habitats in South Africa and SWAustralia

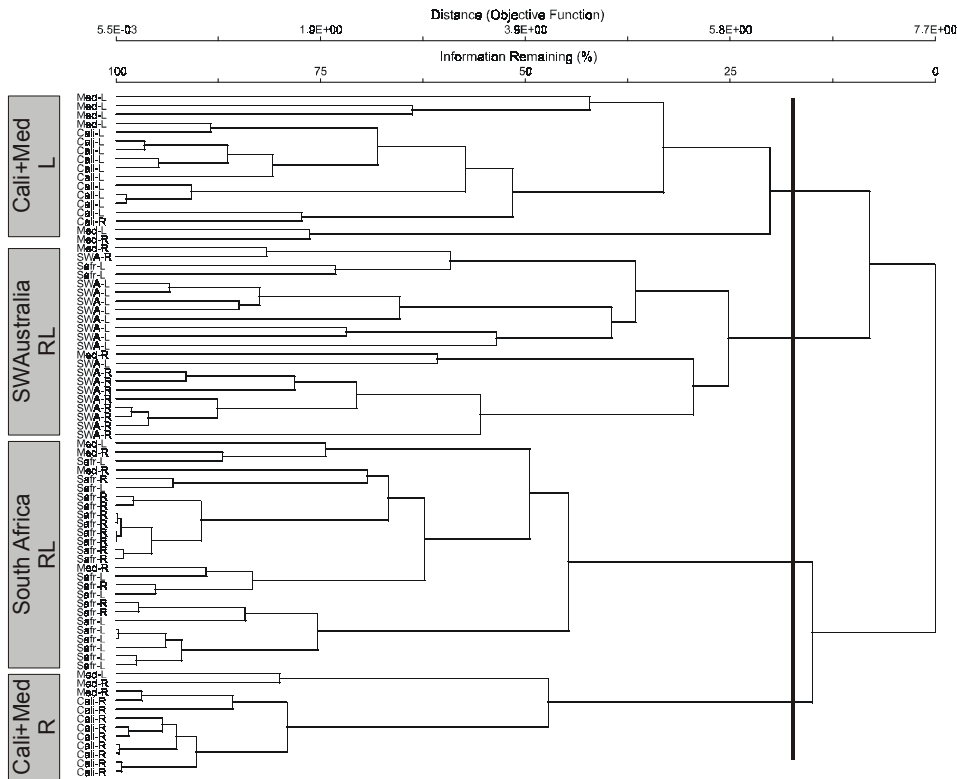


Figure 10. Bray-Curtis cluster with common matrix and riffles and pools reference sites.

but not for MedBasin and California. In northern hemisphere med-regions, common taxa have a similar composition and abundance in each habitat independently of the region, especially in pools. Riffles in MedBasin, although they are closer to the Californian ones, have a higher variability in composition and abundance and are closer to SWAustralia and South Africa than to lentic habitats of Med-Basin and California. However, for each region independently and all taxa, MRPP results (Table 5) show that in studied sites all med-regions have significant differences between the macroinvertebrate assemblage of riffles and pools. Number of taxa is similar between R and L in all regions (Figure 11 and Table 8), but some differences are found with the rest of metrics. EPT/OCH ratio is significant higher in R than L in all med-regions except for South Africa ($p>0.005$) (Table 8). SWAustralia and South Africa have a significant higher number of dipterans in R compared with MedBasin and California. Percentage of non-insect taxa only displays significant differences among habitats in South Africa where a lower number of non-insect taxa are observed in R than L.

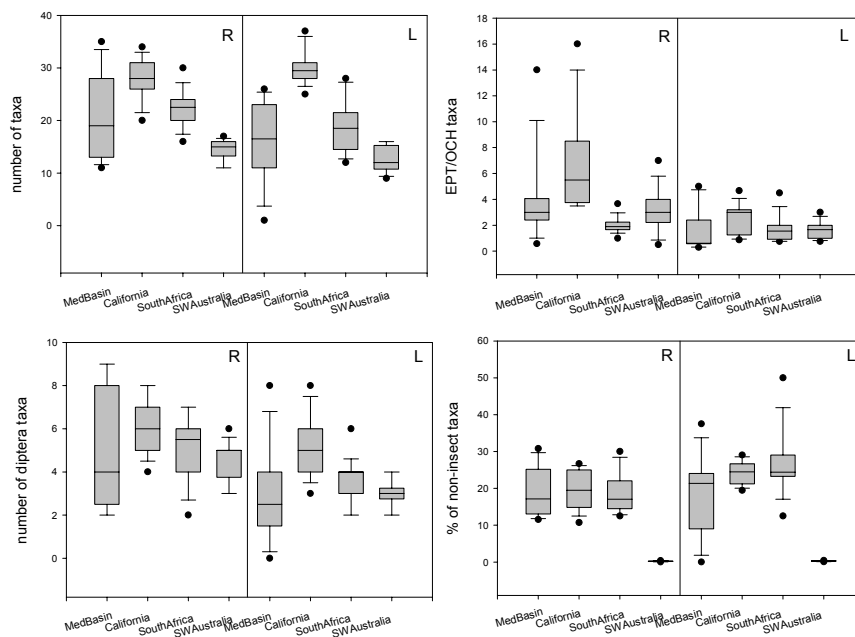


Figure 11. Box-Plot between riffles and pools for reference sites.

Table 8. Kruskal-Wallis non-parametric tests between med-regions and habitat. R=riffles and L=pools. * p<0.05 and **p<0.001.

| | | Taxa | EPT/OCH | Dipterans | %Non-insect |
|-----------------|-----------------------------|-----------------|-----------------|------------------|--------------------|
| R among regions | <i>Chi-squared K-W test</i> | 15.76 | 19.51 | 5.25 | 11.91 |
| | <i>p-value</i> | 0.0013** | 0.0002** | 0.1539 | 0.0077** |
| L among regions | <i>Chi-squared K-W test</i> | 19.48 | 2.6 | 17.07 | 15.46 |
| | <i>p-value</i> | 0.0002** | 0.4575 | 0.0007** | 0.0015** |
| MedBasin | <i>Chi-squared K-W test</i> | 0 | 4.666 | 1 | 0.253 |
| | <i>p-value</i> | 1 | 0.0308* | 0.3173 | 0.6143 |
| California | <i>Chi-squared K-W test</i> | 0.202 | 9.8989 | 1.8181 | 3.2 |
| | <i>p-value</i> | 0.6531 | 0.0017** | 0.1775 | 0.0736 |
| South Africa | <i>Chi-squared K-W test</i> | 2.7428 | 2.666 | 8.7111 | 6 |
| | <i>p-value</i> | 0.0977 | 0.1025 | 0.0032** | 0.0143* |
| SW Australia | <i>Chi-squared K-W test</i> | 0.9 | 7.244 | 5.555 | 2 |
| | <i>p-value</i> | 0.3428 | 0.0071** | 0.0184* | 0.1573 |

When habitats are considered separately, several differences between med-regions are found in all metrics. Thus, California has a higher number of taxa in R and L separately, a higher EPT/OCH ratio in riffles and a higher number of dipterans in L, compared with the rest of med-regions. Significant differences found in the percentage of non-insect fauna are because of the lower values found in SWAustralia in both habitats separately, in contrast with the observed in the rest of sampled areas (Table 8).

Convergences and divergences between habitats in med-regions are given in detail in Table 9, where IndVal results are presented. The significant families and the ones with a high IV-value but non-significant have to be understood in terms of presence and relative abundance of each taxa in each region. Hydropsychidae and Simuliidae are significantly abundant in riffles in all med-regions, whereas other taxa are exclusive from one, two or three regions. All the plecopterans found in MedBasin and California and the respective families found in southern hemisphere (Notonemouridae and Gripopterygidae) have higher IV-value in riffles than in pools. Within the Ephemeropterans, Ephemerellidae is typical from riffles in California and MedBasin, and the close family Teloganodidae is in South Africa. Heptageniidae is a common family found in riffles in MedBasin and California, but without habitat preferences in South Africa and absent in SWAustralia. Differences in habitat preferences are found in

Table 9. IndVal results between riffles and pool habitats for each med-region. Line separates taxa significant at $p < 0.05$ from not significant. Non-significant taxa are from high indicator values (IV) to low. Only taxa with IV higher than 25 are presented (Düfrené & Legendre, 1997).

| MEDBASIN | | | | |
|------------------|----|---------|-------------------|------------|
| Riffles | IV | p-value | Pools | IV p-value |
| Hydropsychidae | 63 | 0.03 | Gerridae | 87.5 0 |
| Simuliidae | 63 | 0.03 | Dytiscid | 62.5 0.02 |
| EphemereIIDae | 60 | 0.07 | Hydrometridae | 45.5 0.21 |
| Ceratopogonidae | 55 | 0.21 | Culicidae | 37.5 0.2 |
| Chironomidae | 54 | 0.56 | Hydrophilidae | 37.5 0.2 |
| Nemouridae | 51 | 0.12 | Coenagrionidae | 37.5 0.21 |
| Elmidae | 51 | 0.11 | Hydracarina | 37.5 1 |
| Chloroperlidae | 50 | 0.08 | Leptophlebiidae | 33.7 0.89 |
| Erpobdellidae | 50 | 0.08 | Polycentropodidae | 27.3 0.6 |
| Hydroptilidae | 50 | 0.08 | Nepidae | 25 0.46 |
| Perlodidae | 50 | 0.09 | Notonectidae | 25 0.47 |
| Limnephilidae | 49 | 0.5 | Hydrobiidae | 25 0.47 |
| Perlidae | 44 | 0.12 | | |
| Betidae | 43 | 0.61 | | |
| Heptageniidae | 42 | 0.33 | | |
| Oligochaeta | 40 | 0.8 | | |
| Tabanidae | 38 | 0.2 | | |
| Leuctridae | 38 | 0.2 | | |
| Hydraenidae | 33 | 0.34 | | |
| Sericostomatidae | 31 | 0.33 | | |
| Ostracoda | 29 | 0.77 | | |
| Caenidae | 29 | 0.8 | | |
| Empididae | 30 | 0.43 | | |
| Rhyacophilidae | 27 | 0.54 | | |
| Glossosomatidae | 25 | 0.47 | | |
| Limoniidae | 25 | 0.47 | | |

| CALIFORNIA | | | | |
|-------------------|------|---------|-------------------|------------|
| Riffles | IV | p-value | Pools | IV p-value |
| Hydropsychidae | 93.3 | 0.001 | Gerridae | 84.4 0.002 |
| Simuliidae | 87.8 | 0.001 | Dytiscidae | 74.1 0.005 |
| Tipulidae | 73.5 | 0.005 | Sialidae | 60 0.007 |
| Rhyacophilidae | 72 | 0.008 | Leptophlebiidae | 64.3 0.027 |
| Perlidae | 68.2 | 0.016 | Ceratopogonidae | 60 0.077 |
| Baetidae | 56.2 | 0.017 | Ostracoda | 58.4 0.068 |
| Chloroperlidae | 66.7 | 0.031 | Lepidostomatidae | 56.8 0.07 |
| Heptageniidae | 60 | 0.085 | Chironomidae | 50 1 |
| EphemereIIDae | 58.2 | 0.139 | Limnephilidae | 46.2 0.296 |
| Oligochaeta | 57.4 | 0.188 | Calamoceratidae | 40 0.09 |
| Elmidae | 55.8 | 0.187 | Gomphidae | 40 0.106 |
| Nemouridae | 53.6 | 0.269 | Oribatidae | 40 0.121 |
| Hydracarina | 51.9 | 0.744 | Sericostomatidae | 35.6 0.179 |
| Empididae | 48.7 | 0.516 | Physidae | 34.3 0.555 |
| Philopotamidae | 45.5 | 0.07 | Corixidae | 33.3 0.228 |
| Polycentropodidae | 43.6 | 0.064 | Sphaeridae | 32 0.299 |
| Hydroptilidae | 42 | 0.43 | Nematoda | 31.2 0.646 |
| Glossosomatidae | 36.7 | 0.443 | Cordulegasteridae | 30 0.204 |
| Sephenidae | 35 | 0.707 | Aeshnidae | 30 0.232 |
| Peltoperlidae | 34.3 | 0.247 | Dixidae | 30 0.998 |
| Dugesidae | 32 | 0.225 | | |
| Uenoidae | 31.1 | 0.341 | | |
| Brachycentridae | 26.7 | 0.522 | | |

| SOUTH AFRICA | | | | |
|-----------------|----|---------|-----------------|------------|
| Riffles | IV | p-value | Pools | IV p-value |
| Simuliidae | 78 | 0 | Ostracoda | 55.3 0.06 |
| Hydraenidae | 74 | 0 | Oligochaeta | 53.8 0.23 |
| Philopotamidae | 67 | 0 | Nematoda | 44.9 0.66 |
| Teloganodidae | 62 | 0.01 | Ceratopogonidae | 39.7 0.68 |
| Notonemouridae | 67 | 0.01 | Ecnomidae | 30 0.64 |
| Blepharoceridae | 55 | 0.01 | Coenagrionidae | 28.6 0.22 |
| Hydropsychidae | 53 | 0.02 | | |
| Leptophlebiidae | 63 | 0.02 | | |
| Baetidae | 58 | 0.08 | | |
| Elmidae | 57 | 0.11 | | |
| Helodidae | 55 | 0.17 | | |
| Chironomidae | 52 | 0.15 | | |
| Hydracarina | 51 | 0.53 | | |
| Empididae | 49 | 0.15 | | |
| Tipulidae | 48 | 0.06 | | |
| Leptoceridae | 44 | 0.81 | | |
| Glossosomatidae | 38 | 0.12 | | |
| Corydalidae | 33 | 0.1 | | |
| Potamonantidae | 25 | 0.21 | | |

| SWAUSTRALIA | | | | |
|------------------|------|---------|--------------|------------|
| Riffles | IV | p-value | Pools | IV p-value |
| Simuliidae | 90.3 | 0.001 | Leptoceridae | 59.3 0.146 |
| Hydropsychidae | 88.9 | 0.001 | Ostracoda | 47.6 0.122 |
| Ceratopogonidae | 62.5 | 0.08 | Dytiscidae | 35.6 0.279 |
| Griptopterygidae | 60.4 | 0.12 | Corduliidae | 35.4 0.557 |
| Oligochaeta | 60.3 | 0.134 | Gomphidae | 29.6 0.621 |
| Leptophlebiidae | 54.5 | 0.232 | Caenidae | 25.9 0.372 |
| Chironomidae | 50.9 | 1 | Ecnomidae | 25 0.583 |
| Empididae | 46.3 | 0.116 | | |
| Aeshnidae | 38.1 | 0.581 | | |
| Hydrobiosidae | 33.3 | 0.206 | | |
| Athericidae | 33.3 | 0.349 | | |
| Nematoda | 33.3 | 0.588 | | |
| Baetidae | 25 | 0.353 | | |

Leptophlebiidae that have a high IV-value in riffles in California, South Africa and SWAustralia but not in MedBasin, where is classified as a pool-specie. The Coleopterans Elmidae and Hydraenidae are present in riffles in the regions where they were found: MedBasin, California and South Africa. The Dipteran Ceratopogonidae is characteristic from riffles in MedBasin and SWAustralia but from pools in California and South Africa. The highly abundant Chironomidae is a riffle-family in MedBasin, South Africa and SWAustralia but not in California. Several non-cased caddisflies as Rhyacophilidae in MedBasin and California, Polycentropodidae in California, Hydrobiosidae in SWAustralia are common in riffles jointly with the stony-case caddisflies as Glossosomatidae. Other cased caddisflies, as Sericostomatidae, have a high IV-value in riffles in MedBasin but in pools in California. On the other hand, Leptoceridae have a high IV-value in riffles in South Africa but in pools in SWAustralia.

Odonata, Heteroptera and Coleoptera are dominant taxa in pools. Dytiscidae, Gerridae, Leptophlebiidae and Culicidae are tolerant lentic families shared between MedBasin and California. At the same time, Dytiscidae is also characteristic and abundant in SWAustralia. California have a longer list of families with a high IV-value compared with MedBasin, with Gomphidae, Cordulegasteridae and Aeshnidae, together with the woody-cased caddisflies Lepidostomatidae, some Limnephilidae and Calamoceratidae. Some Mollusca very abundant in pools in MedBasin as Hydrobiidae are not significantly present in California but others with a high IV-value as Physidae were collected. In southern hemisphere fewer number of Mollusca taxa was found. The Odonata Coenagrionidae is a shared and abundant family in pools in MedBasin and South Africa, whereas Gomphidae is in California and SWAustralia. Ostracoda have been collected in all med-regions, but were more significantly found in pools in California, South Africa and SWAustralia.

Comparisons between common and characteristic community according to habitat preferences between pairs of med-regions were performed and the results are plot in Figure 12. Higher similarities between riffles and pools are observed between regions than the between permanent and temporary sites. All med-regions have convergent responses of the common taxa in front of reophilia, with 80% of similarity between California and South Africa and SWAustralia. MedBasin also have high similarities with the rest of med-regions, with over than 64% with South Africa, and around 70% with California and SWAustralia. On the other hand, the percentage of similarity between South Africa and SWAustralia appears to be lower than the observed when permanent and temporary conditions are compared.

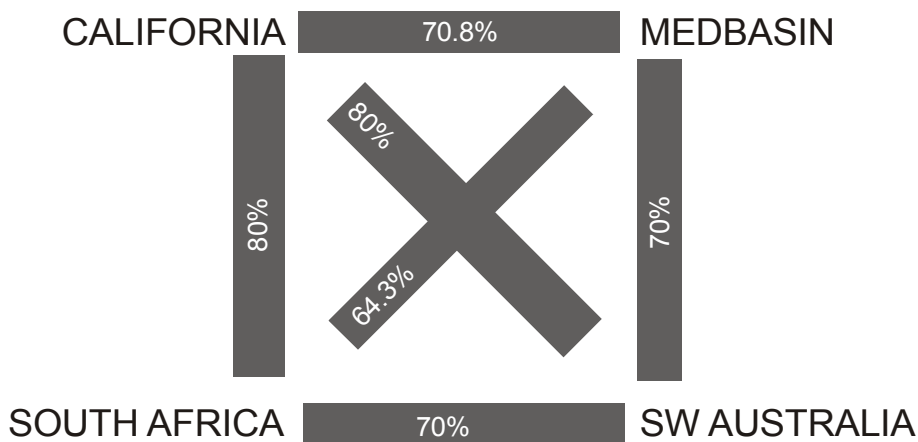


Figure 12. Percentages of similarity between med-regions considering common abundant and representative (IV-value) taxa in riffles and pools habitats.

DISCUSSION

Traditionally, convergence in ecology has had a deterministic framework, where communities developed under similar conditions would have a common structure (Cody & Mooney, 1978). However, several approaches argue that historical factors and intrinsic indeterminism can imply divergence even under similar environments (Samuels & Drake, 1997). The scale of study is important to check for global convergences and divergences between regions, as some scales of observation can obscure others (Samuels & Drake, *op. cit.*). Overall, our study has focused at two levels with the mediterranean climate as a common denominator: regional and local.

Regional scale: historical factors

Appropriate taxonomical sufficiency in aquatic studies has been highly discussed in stream ecology, and especially in bioassessment (Resh & Unzicker, 1975; Cranston, 1990; Marchant *et al.*, 1995; Bowman & Bailey, 1997). Although the use of a low taxonomical resolution implies a gain in precision and information in the responses (Furse *et al.*, 1984; Resh *et al.*, 1995), at large scale, when different regions in the world are compared in taxonomical composition and ecological responses, higher taxonomical levels can be more useful as

speciation have acted in a different way in each region. On the other hand, several authors have demonstrated that ecological patterns observed at higher taxonomical levels are equivalent to the ones at genus or species (e.g. Furse *et al.*, 1984; Ferrano & Cole, 1992; Rutt *et al.*, 1993; Marchant *et al.*, 1995). However, because the high speciation present in some families (e.g. Leptoceridae in southern hemisphere —de Moor, 1988, 1997) some divergences observed between med-regions could be attributed to dissimilar ecological responses because of the existence of different genus and species between regions. When detailed taxonomical information is not available, comparisons at genus or species level are impossible. In this case, as in our study, studies at higher taxonomic level may provide interesting insights about the importance of historical and ecological factors (Ricklefs, 1987).

According to the results obtained, when macroinvertebrate assemblages at family level are studied in the 5 med-regions in the world, the historical factor seems very important in determining macroinvertebrate community of streams in med-regions (see Figure 13 for summary). Convergences found between med-regions in macroinvertebrate community are unlikely related to the climate because of the short history of the mediterranean climate (Alxelrod, 1973; Suc, 1984), and seems to be related to previous historical factors. Notable differences are found between northern and southern hemisphere, as the early breakup between Laurasia and Gondwanaland during the Cretaceous (70-135 myBP). As in plant communities (Deacon, 1983), macroinvertebrates from boreal med-regions are highly convergent, because the connections between both regions until the Eocene by Bering bridge (Deacon, 1983), whereas macroinvertebrates in southern hemisphere are more divergent between med-regions because the early break up of Gondwanaland in early Cretaceous. This strong convergence observed between MedBasin and California implies lower exclusivity of taxa in both regions at family level. On the other hand, some exclusive families in MedBasin or California have a wider distribution than med-region it self. For instance, Prosopistomatidae or Polymitarciidae from MedBasin are also found in African areas (Edmunds, 1972), and Pteronarcyidae or Peltoperlidae in California have been recorded in other Neartic and Asian regions (Zwick, 2000).

High convergences have been reported in plants between California and Chile because the exchange of taxa through the Panama isthm, 3 My ago (Naveh & Wittaker, 1979; Di Castri, 1991). Contrary to that, our study shows that Chilean macroinvertebrate community have a weak convergence with California med-region at family level, what could be related with the faster dispersion of plants in front of invertebrates (Cox & Moore, 1993) and the lowest richness by the insular situation of the country between Andes, Atacama desert and Pacific

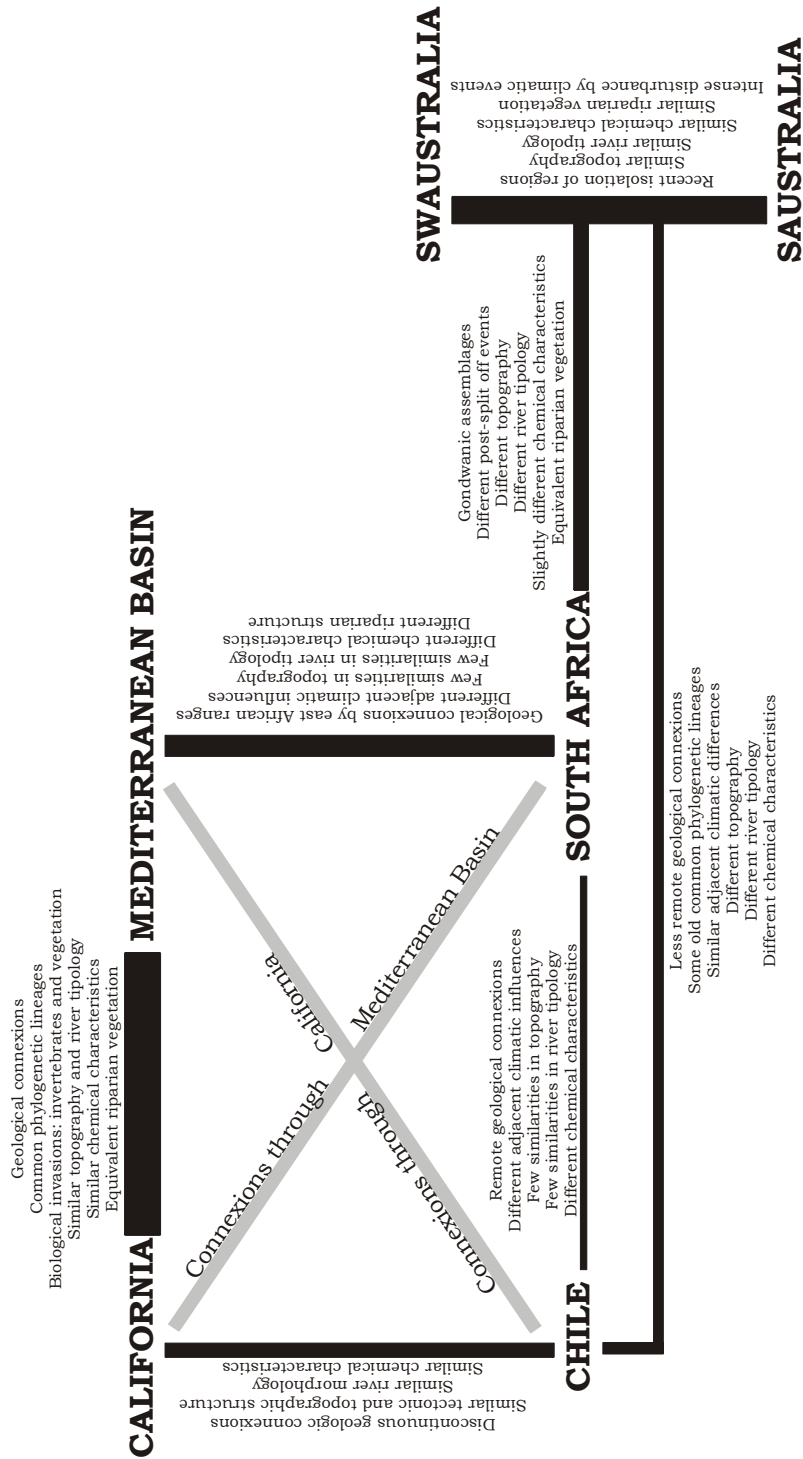


Figure 13. Convergence graph among mediterranean regions. The line width is a representation of the degree of similarity between mediterranean areas.

ocean (Armesto *et al.*, 1997). However, several taxa originated in northern hemisphere are present in Chile and absent in other southern med-regions, as Limnephilidae, Psychomyiidae, Perlidae or Notonemouridae (nowadays extinct in northern hemisphere —Zwick, 2000). These cold-temperate fauna could have arrived to Chile through Panama isthm and be established because of the local conditions provided by Andes ranges. On the other hand, as in plant community (Naveh & Wittaker, 1979), we found that Chile have a weak convergence between med-regions in southern hemisphere in macroinvertebrates. However, more families are shared with Australia than South Africa because of the connections between the Neotropical and Austral areas until late Cretaceous (Brundin, 1965; Harrison, 1978).

As it has been seen in plants (Cowling, 1992), macroinvertebrate assemblage in South African med-region is more convergent to tropical adjacent areas and northern hemisphere than to Chile or Australia. This relationship with the boreal area would indicate an active migration during Miocene or Pliocene, of organisms originated in the Palearctic and Nearctic area through the south by the African uplands, as for example some coldstenotermous macroinvertebrates (Heptageniidae, Notonemouridae, Lepidostomatidae and Goeridae). Moreover, some convergences between South Africa and the Holartic area as the Tricorythidae originated in Africa (Edmunds, 1972), would explain that exchange in a different direction were also probable. However, not all taxa originated in northern hemisphere or tropical adjacent areas are found in the med-region. For instance, Perlidae, Sialidae, Oligoneuridae, Palaemonidae, Calamoceratidae or Psephenidae lack in Western Cape, although that does not imply a lost of convergence between northern hemisphere areas. In spite of that, we have found few similarities between South Africa and Australia (Notonemouridae, Chlorolestidae, Protoneuridae with SAustralia, and Athuridae and Amphisopodidae with SWAustralia). Day *et al.* (2001) pointed out that more convergences in crustaceans should have existed before the end of Cretaceous when an important drought affected South Africa, extinguishing many taxa.

Although closer in space, SWAustralia and SAustralia are more divergent in macroinvertebrates than California and MedBasin. This fact can be explained by the presence of an extreme arid period around 18000 yBP ago (DeDeckker, 1986) that affected SWAustralia region, implying several taxonomical extinctions and isolating this area from the east by 1000 km of desert. Consequently, further colonizations of macroinvertebrates from the east coast to the southwest were difficult and a low number of fauna in the southwest has been noticed by Bunn & Davies (1990).

In spite of these observed divergences between macroinvertebrate assemblage in med-region, numerous ubiquitous taxa are present, what implies the existence of similar evolutionary mechanisms of dispersion, extinction and adaptation of the taxa along time (Deacon, 1983). Because of the dispersion and colonization of one organism depends on the environmental conditions and life cycles (Cox & Moore, 1993), organisms with short life cycles, continuous reproductions and aerial phases should be easily dispersed, and therefore they will have a wider distribution (Williams & Feltmate, 1993). Baetidae, Caenidae, Leptophlebiidae, Leptoceridae, Hydropsychidae, Oligochaeta and almost all dipterans are ubiquitous taxa, and most of them have been considered as organisms easily to disperse because their morphological and reproductive traits (for example see Gray, 1981; Gray & Fisher, 1981; Fisher *et al.*, 1982). Moreover, most of these taxa are characterized by having a very old origin (e.g., Baetidae, Caenidae and Leptophlebiidae) in contrast with others with a local distribution (e.g., Teloganodidae — Edmunds, 1972).

Historical factors are important to understand taxonomical convergences and divergences, but the viability and success of one taxa in one new region will depend on the local and environmental conditions (Resh & Solem, 1996). In that sense, Ball (1975) distinguishes between an analytical (Historical Biogeography) and an empirical biogeography (Ecological Biogeography). Thus, the abundance of EPT in Northern hemisphere and Chile respect other areas could be interpreted by the mountain river typology of some rivers flowing from high mountains near the coast (Sierra Nevada in California, Andes in Chile and Sierra Nevada, Pyrenees, Apennines, Atlas,... in Med-Basin), that let the establishment of species adapted to steep, cold and fast flowing rivers. On the other hand, even though some mountainous and high gradient rivers with cold waters are present in South Africa and SAustralia, the low EPT/OCH is explained by the poor contribution of Plecoptera in these regions because of biogeographical factors (Zwick, 2000), instead of environmental ones. This difficulty to discern between ecological and historical factors has been emphasized by Endler (1982), but both have to be present to understand community structure and composition (Ricklefs, 1987; Menge & Olson, 1990).

Local scale: Ecological factors and the spatio-temporal variability

In our study and according to the measured factors in reference conditions (without human disturbance), pH is a key variable to diferenciate med-regions. Calcareous geology in mediterranean basin (di Castri, 1981) is the responsible of a high pH in its rivers and streams (Toro *et al.*, (in press)), whereas heavily washed soils in South Africa and SWAustralia (Specht & Moll, 1983), provide a high acidity in reference conditions. In South Africa, fynbos vegetation

accentuates this phenomenon supplying highly concentrations of humic acids to the water (Midgley & Schafer, 1992). This gradient of med-regions in pH is followed by temperature in a contrary sense, related with local and microclimatic factors. For example, sites located near high mountains in California or MedBasin should have a lower temperature than the ones in the plains or coastal areas (Hornbeck *et al.*, 1983; Robles *et al.* (in press)).

This variability of physical and chemical factors and the high diversity in landscape topography between med-regions, influence the presence and abundance of several macroinvertebrate's taxa. Thus for instance, Mollusca are infrequent in South Africa because the acidic and oligotrophic conditions (Harrison & Agnew, 1962; Brown, 1978), but are abundant in Med-Basin localities with a calcareous geology (Martínez-López *et al.*, 1988; Gallardo-Mayenco *et al.*, 1994; Habdija *et al.*, 1995). However, mixed with local factors, historical events can also influence the abundance of some taxa respect others. For example, Leptoceridae and Leptophlebiidae are very abundant in South Africa and SWAustralia, because of its large diversification in southern hemisphere (de Moor, 1988, 1997; Edmunds, 1972). Consequently, a combination of local and historical factors appear, once again, as the responsible of the convergences and divergences observed in med-regions.

Disturbance (e.g., floods and droughts) is a key element to understand biodiversity in streams (Resh *et al.*, 1988; Vinson & Hawkins, 1998) independently of historical events. The response of a system to disturbance depends on the degree of stability (Wishart, 1998) and its frequency and intensity (Resh *et al.*, 1988). We should expect that annual discharge variation in mediterranean rivers (Gasith & Resh, 1999) could imply similar responses to the effect of temporality between med-regions except in extreme cases (e.g., in a more semiarid or arid areas), where the high unpredictability in the intensity and frequency of the occurrence of rainfall and discharge (Vidal-Abarca, 1990) would emphasize the differences between temporary and permanent sites.

Several comprehensive studies about the effect of droughts have been done in different regions in the world (see Boulton & Suter, 1986; Williams, 1987; Boulton & Lake, 1992ab). This flow disturbance induces an adapted macroinvertebrate community (Williams & Hynes, 1977; Williams, 1987; Delucchi & Peckarsky, 1989; Sommerhäuser *et al.*, 1997) in terms of resilience and resistance (Stanley & Fisher, 1992) with the former more important in temporary streams (Grimm & Fisher, 1989). Studies performed in mediterranean rivers also suggest that, temporary rivers and streams have macroinvertebrates of smaller size with

multivoltine life cycles (Bonada *et al.*, Chapter 5), but at the same time adapted taxa have also developed.

Disagreements exist comparing differences between richness in permanent and temporary sites. For instance, Wrigth *et al.* (1984) or del Rosario & Resh (2000) found lower richness in temporary than permanent sites, whereas Legier & Talin (1973), Boulton & Suter (1986) or Miller & Golladay (1996) report similar number of taxa. In our case, similar richness has been recorded for all regions among permanent and temporary sites in springtime. But despite the similar species richness between permanent and temporary sites in all regions, several differences appear, specially when SWAustralia is compared with other regions. Bunn & Davies (1990) pointed out that the fauna in SWAustralia is depauperate compared with the one found in the east side of the continent, because the isolation of the SW and the previous history, that caused that permanent taxa with longer life cycles (e.g., Oligoneuridae, Siphonuridae, Austroperlidae, Eustheniidae, Calocidae or Helicophidae) disappeared in the past, and further colonizations were difficult. Then, the taxa typical from permanent sites are absent in this area, what would explain the similarities between permanent and temporary sites in this med-region, although the higher precipitation occurred in the area one year before sampling, respect the other med-regions, could be also another reason. On the other hand, Boulton & Lake (1992) studying several temporary sites in Australia and their nearby permanent ones found a significant faunal overlap, not found in other studies in northern hemisphere (Williams & Hynes, 1976; Casey & Ladle, 1979; Wrigth *et al.*, 1984). In that sense, Wishart (1998) suggest that there are different responses to temporality between northern and southern hemisphere, with higher differences between permanent and temporary communities in northern because of more stable rivers are present.

Looking for differences between several insect orders, we found riffle taxa (EPT) with higher abundance values in permanent sites, and a mixing of riffle and lentic communities (OCH and some EPT) in temporary ones. That would suggest that differences between permanent and temporary sites are consequence of a different proportion of riffles and lentic habitats. Legier & Talin (1973) in a study in several French mediterranean temporary and permanent rivers pointed out that some lotic taxa were absent in temporary sites, as Rhyacophilidae, Heptageniidae, Goeridae or Perlidae, and a similar pattern we have found in Med-Basin, California and South Africa. On the other hand, Boulton & Lake (1992a) studying several temporary sites, found more taxa and individuals in pools than in riffles. Consequently, in springtime even though the temporary rivers still present some riffles and pools, a major

presence of pools taxa indicates a restructuring community adapting to intermittency and ephemerally of waters in summertime.

From our results, differences in taxa richness and abundance between riffles and pools (R vs. L) seem to be more important than temporality and consequently more convergent between med-regions. In fact, Delucchi (1988) noticed higher differences between riffles and pools than temporary and permanent sites, which agree with our results.

All sampled med-regions have a similar number of taxa between riffle and lentic habitats, as has been shown in elsewhere (e.g., Scullion *et al.*, 1982; Logan & Brooker, 1983, but see Brown & Brussock, 1991; Boulton & Lake, 1992a or McCulloch, 1986). However, composition differs between habitats looking at order or family assemblage, as has been reported by many studies (e.g., Logan & Brooker, 1983). Riffles in mediterranean rivers hold a higher number of Ephemeroptera, Plecoptera and Trichoptera in front of Odonata, Coleoptera and Heteroptera, because of their different hydraulic requirements (Statzner *et al.*, 1988). This pattern has also been observed in other areas far away from mediterranean regions, as in a more temperate area in England (Scullion *et al.*, 1982) or more arid in North America (McCulloch, 1986). Strong similarities are also observed looking at the exclusive fauna found in riffles and pools, when our results are compared with other studies around the world (e.g., see Rabeni & Minshall, 1977; Armitage *et al.*, 1974; Scullion *et al.*, 1982; McCulloch, 1986; Malmqvist *et al.*, 1993), what would indicate that differences between habitats in macroinvertebrate community are independent of mediterranean climate. However, climatic patterns can influence in the proportion of riffles and pools in a reach along the year, losing riffles as the drought is coming (Gasith & Resh, 1999; Bonada *et al.*, Chapter 4).

Regional and local richness in mediterranean rivers

In any region, richness of plants or animals is a product of the balance between processes acting at different scales (Ricklefs, 1987; Tonn *et al.*, 1990). Regional richness (by history factors) have been obtained using all accumulated taxa recorded in each med-region, whereas local richness (by ecological factors) may be referred to the number of taxa collected per sampling site.

Traditionally, stream ecologists have focused on the Thienemann's principles (Thienemann, 1954) where richness is a function of frequency and magnitude of physical disturbance, indicating a highest richness at intermediate levels of disturbance (e.g., Minshall, 1988; Sousa, 1994). Poff & Ward (1989) classified North American streams according to degrees of

intermittency, flood frequency and predictability and flow predictability suggesting highest richness under high flow predictability by low in high flood and drought frequency. Mediterranean rivers, are characterized by predictable disturbances (floods and droughts) (Gasith & Resh, 1999) what would imply a higher regional richness compare with other climatic regions where floods and droughts are more extreme and less predictable. Consequently, although the intensity and frequency of this discharge disturbance is unpredictable (Vidal-Abarca, 1990; Gasith & Resh, 1999) regional richness found in med-regions (as number of family taxa) appears is very high, except for SWAustralia, where historical events constrained a major number of taxa (Bunn & Davies, 1990). Values of richness obtained from this study are difficult to compare with other climatic areas because no comparative studies between climates have been performed. However, some extensive studies performed elsewhere may be useful. Thus, for example, an extensive study in NWAustralia, under two climates, 90 macroinvertebrate families were collected, 77 in the tropical wet-dry climate and 73 and 61 in the desert one (Kay *et al.*, 1999), values lower than the found in med-regions. Studies in plant biology agree with this high biodiversity in med-regions (Raven 1973; Deacon, 1983), what exhibit that under intermediate stress conditions a high biodiversity can be hold. The explanation may be found in the predictability of events (floods and droughts) in the mediterranean climate (Gasith & Resh, 1999) and the presence of resilient and resistant adaptations to these disturbances by evolutionary forces acting since the begining of the earth history.

According to Ricklefs (1987) the relationship between regional and local richness indicate the relative importance of regional and local processess influencing local richness. Thus, if med-regions with different regional richness have similar local richness, local processes are important, whereas if a positive relationship between regional and local richness is present, regional factors dominate. Figure 14 displays the relationship between regional and local richness in the sampled med-regions. The relationship is positive between SWAustralia, South Africa and California. Regional processes are important to determine local diversity in these areas because their different biogeographic history. However, although MedBasin presents the highest regional richness, it displays a highly variable intermediate local richness, indicating that there is a regulation of local richness by local factors. This phenomena does not agree with Shmida (1981) who comparing vegetation of chaparral and coastal sage between Israel and southern California found four time more regional richness and two times local richness in Israel than in California. MedBasin region present a changing topography, landscapes and microclimates (see Plate 2) that originate numerous river types (e.g., ramblas, short and nival-influence rivers, karsts,...). In this situation, different local factors (biotic or abiotic) can act

more or less severely modulating richness and making it highly variable between sites. On the other hand, this high variability in river typology and several historical events may be the responsible to the highest value of regional richness found in MedBasin. Thereby, the presence of such typologies could allow the presence and survival of some specific taxa and at the same time modulate local richness.

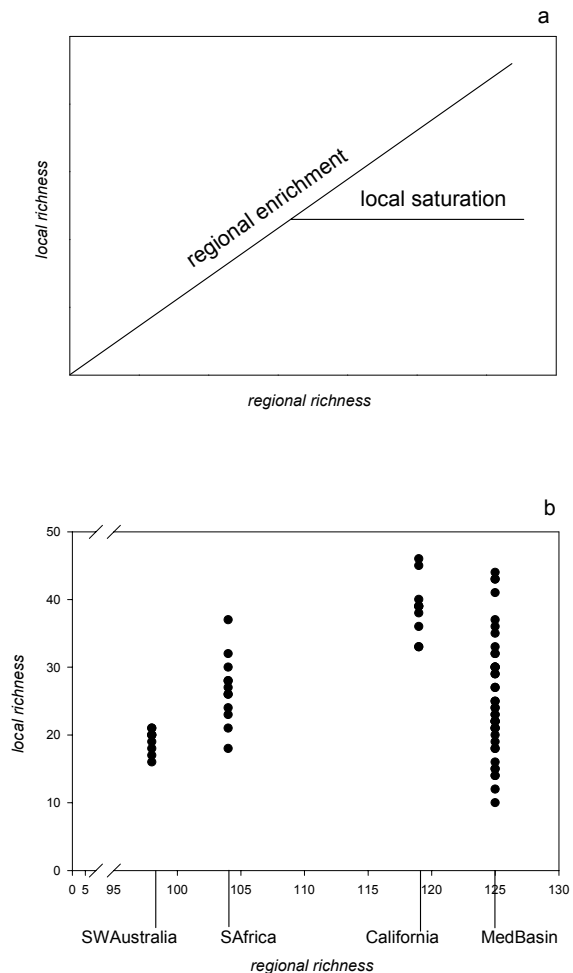


Figure 14. Relationship between regional and local richness. In Figure 14a, model from Ricklefs (1987) is presented. In Figure 14b the application of the model to collected data in med-regions and the approximate curve is plot.

Other convergences and divergences between med-regions

Convergences and divergences between med-regions have been established looking at the community structure. However, communities may display different structure in distant regions, but present similar patterns in feeding or behavioural strategies. Because unavailable data in some med-regions, we were not able to compare trophic relationships under similar climatic conditions. However, some observations can be made from our study. For example, in southern Hemisphere, where the predators Rhyacophilae lack by historical factors, they are replaced by other macroinvertebrates with similar feeding requirements, as the Corydalidae in South Africa. However, in some cases, some feeding strategies are not replaced because again, local factors constrain them. That is the case of South Africa, where its oligotrophic and acidic waters (King *et al.*, 1979) constrain the presence of grazers in headwaters, appearing downstream.

Concluding remarks

Historical and ecological factors have been used in our study to check for differences between macroinvertebrate communities in med-regions. In all cases, northern hemisphere regions have strong convergences compared with the rest of med-regions, and a closer similarity with South Africa than SWAustralia is noticed. Scale of study and the interchange of information between scales have been a problem for ecologists (Levin, 1992). Difficulties are found to define and establish what are large and small scales (Peckarsky *et al.*, 1997). We argue that under the same climatic constraints both historical and local factors are important to macroinvertebrate communities. Convergences or divergences in historical and ecological factors among med-regions let us to understand convergences or divergences in macroinvertebrate community, although other factors as the incidence of non-native macroinvertebrates could affect similarities and differences between med-regions. Consequently, in reference conditions, history, climate, landscape, temporality, habitat and biotic interactions can be considered as filters acting as mechanistic factors in a hierarchical direction, allowing the presence and enhancing the abundance of several species in front of others (Tonn *et al.*, 1990; Poff, 1997). Comparisons in common taxa between med-regions suggest that historical and ecological factors could be more important than climate to determine the abundance of several taxa in a specific habitat or flow condition. However, when such factors let the abundance of some taxa in several regions (e.g., the high pH in California and MedBasin enhance the presence of Mollusca), responses to habitat and temporality between med-regions are highly convergent. From our data, more similarities have been observed between pairs of med-regions in habitat than in flow conditions, suggesting that

habitat has more effect on the macroinvertebrate community than temporality, as has been pointed out by Delucchi (1998).

Responses to temporality and habitat in mediterranean rivers suggest the existence of an habitat template (Southwood, 1977; Poff & Ward, 1990; Townsend and Hildrew, 1994) modulated by mediterranean climate, where the evolution acted establishing adaptative convergences in macroinvertebrates between med-regions, whereas divergences may be related to topographic, litologic or historical factors. Further studies focused on biological or ecological species traits should be done to provide more information about similar response under common flow disturbances and habitat heterogeneity independently of similarities and differences between macroinvertebrate assemblages. Moreover, comparative information about the annual and interannual changes of macroinvertebrate community between med-regions would help us to understand better the identity and uniqueness of mediterranean rivers.

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Annex 1. Presence and absence of taxa in each mediterranean region.

| | | California | MedBasin | Chile | South-Africa | SW Australia | S Australia |
|---------------------|-------------------|------------|----------|-------|--------------|--------------|-------------|
| PLATHHELMINT | Dugesiidae | 1 | 1 | 1 | 1 | 1 | 0 |
| | Planariidae | 1 | 1 | 0 | 0 | 0 | 0 |
| | Temnocephalidae | 0 | 0 | 1 | 0 | 1 | 1 |
| GORDIIDAE | Gordiidae | 1 | 1 | 1 | 1 | 1 | 1 |
| OLIGOCHAETA | Oligochaeta | 1 | 1 | 1 | 1 | 1 | 1 |
| POLIQUETA | Neiridae | 1 | 0 | 0 | 0 | 0 | 0 |
| | Syllidae | 0 | 0 | 0 | 0 | 0 | 1 |
| AQUETA | Erpobdellidae | 1 | 1 | 0 | 0 | 0 | 1 |
| | Glossiphoniidae | 1 | 1 | 0 | 0 | 0 | 0 |
| | Hirudinidae | 1 | 1 | 0 | 1 | 0 | 0 |
| | Mesobdellidae | 0 | 0 | 1 | 0 | 0 | 0 |
| | Richardsonianidae | 0 | 0 | 0 | 0 | 1 | 1 |
| MOLLUSCA | Amnicolidae | 0 | 0 | 1 | 0 | 0 | 0 |
| | Ancylidae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Bithynellidae | 0 | 1 | 0 | 0 | 0 | 0 |
| | Bithyniidae | 0 | 1 | 0 | 0 | 0 | 1 |
| | Chilinidae | 0 | 0 | 1 | 0 | 0 | 0 |
| | Corbiculiidae | 1 | 0 | 0 | 1 | 1 | 1 |
| | Ferriidae | 0 | 1 | 0 | 0 | 0 | 0 |
| | Hydrobiidae | 1 | 1 | 0 | 1 | 1 | 1 |
| | Hyridae | 0 | 0 | 1 | 0 | 1 | 1 |
| | Lymnaeidae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Neritidae | 0 | 1 | 0 | 0 | 0 | 0 |
| | Physidae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Planorbidae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Pomatopsidae | 0 | 0 | 0 | 0 | 1 | 1 |
| | Sphaeriidae | 1 | 1 | 1 | 1 | 1 | 1 |
| | Thiaridae | 1 | 1 | 0 | 1 | 1 | 1 |
| | Unionidae | 1 | 1 | 0 | 1 | 0 | 0 |
| | Valvatidae | 1 | 1 | 0 | 0 | 0 | 0 |
| | Viviparidae | 0 | 1 | 0 | 0 | 0 | 1 |
| CRUSTACEA | Aeglididae | 0 | 0 | 1 | 0 | 0 | 0 |
| | Amphisopodidae | 0 | 0 | 0 | 1 | 1 | 0 |
| | Anthuridae | 0 | 0 | 0 | 1 | 1 | 0 |
| | Asellidae | 1 | 1 | 1 | 0 | 0 | 0 |
| | Astacidae | 1 | 1 | 0 | 0 | 0 | 0 |
| | Atyidae | 1 | 1 | 0 | 1 | 1 | 1 |
| | Cambaridae | 1 | 1 | 0 | 1 | 0 | 0 |
| | Ceinae | 0 | 0 | 0 | 0 | 1 | 1 |
| | Cirolanidae | 0 | 0 | 0 | 0 | 0 | 1 |
| | Eusiridae | 0 | 0 | 0 | 0 | 0 | 1 |
| | Gammaridae | 1 | 1 | 1 | 0 | 0 | 0 |
| | Grapsidae | 1 | 1 | 0 | 1 | 1 | 0 |
| | Hyalidae | 1 | 0 | 1 | 0 | 0 | 0 |
| | Hymenosomatidae | 0 | 0 | 0 | 0 | 1 | 1 |
| | Janiridae | 0 | 0 | 0 | 1 | 1 | 1 |
| | Mesoveliidae | 1 | 1 | 0 | 0 | 1 | 1 |
| | Munnidae | 0 | 0 | 0 | 1 | 0 | 0 |
| | Oniscidae | 0 | 0 | 0 | 0 | 1 | 1 |
| | Ostracoda | 1 | 1 | 0 | 1 | 1 | 1 |
| | Palaemonidae | 0 | 1 | 0 | 1 | 1 | 1 |
| | Paracalliopidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Paramelitidae | 0 | 0 | 0 | 1 | 1 | 1 | |

| | California | MedBasin | Chile | South-Africa | SW Australia | S Australia |
|----------------------|------------|----------|-------|--------------|--------------|-------------|
| Parastacidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Perthiidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Phreatoicidae | 0 | 0 | 0 | 1 | 1 | 0 |
| Potamonautidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Protojaniridae | 0 | 0 | 0 | 1 | 0 | 0 |
| Samastacidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Spelaeogriphidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Sphaeromatidae | 0 | 0 | 0 | 1 | 1 | 0 |
| Sternophysingidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Talitridae | 0 | 0 | 0 | 0 | 0 | 1 |
| ACARI | | | | | | |
| Hydracarina | 1 | 1 | 1 | 1 | 1 | 1 |
| Oribatidae | 1 | 1 | 0 | 0 | 1 | 1 |
| EPHEMEROPTERA | | | | | | |
| Ameletidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Amelotopsidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Baetidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Caenidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Coloburiscidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Ephemerellidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Ephemeridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Heptageniidae | 1 | 1 | 0 | 1 | 0 | 0 |
| Leptophlebiidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Oligoneuriidae | 1 | 1 | 1 | 0 | 0 | 1 |
| Onicogastridae | 0 | 0 | 1 | 0 | 0 | 1 |
| Polymitarcidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Potamanthidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Prosopistomatidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Siphonuridae | 1 | 1 | 1 | 0 | 0 | 1 |
| Teloganodidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Tricorythidae | 1 | 0 | 0 | 1 | 0 | 0 |
| PLECOPTERA | | | | | | |
| Austronemouridae | 0 | 0 | 1 | 0 | 0 | 0 |
| Austroperlidae | 0 | 0 | 1 | 0 | 0 | 1 |
| Capniidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Chloroperlidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Diamphipnoidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Eustheniidae | 0 | 0 | 1 | 0 | 0 | 1 |
| Gripopterygidae | 0 | 0 | 1 | 0 | 1 | 1 |
| Leuctridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Nemouridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Notonemouridae | 0 | 0 | 1 | 1 | 0 | 1 |
| Peltoperlidae | 1 | 0 | 0 | 0 | 0 | 0 |
| Perlidae | 1 | 1 | 1 | 0 | 0 | 0 |
| Perlodidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Pteronarcyidae | 1 | 0 | 0 | 0 | 0 | 0 |
| LEPIDOPTERA | | | | | | |
| Nymphulidae | 1 | 0 | 0 | 1 | 0 | 0 |
| Pyralidae | 1 | 1 | 1 | 0 | 1 | 1 |
| MECOPTERA | | | | | | |
| Nannochoristidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Eomeropidae | 0 | 0 | 1 | 0 | 0 | 0 |
| MEGALOPTERA | | | | | | |
| Corydalidae | 1 | 0 | 1 | 1 | 0 | 0 |
| Sialidae | 1 | 1 | 1 | 0 | 0 | 0 |
| NEUROPTERA | | | | | | |
| Chaulioididae | 1 | 0 | 0 | 0 | 1 | 0 |
| Osmyidae | 0 | 1 | 1 | 0 | 0 | 0 |
| Sisyridae | 1 | 1 | 0 | 1 | 0 | 1 |
| COLEOPTERA | | | | | | |
| Brentidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Carabidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Colymbetidae | 1 | 1 | 0 | 0 | 0 | 0 |

| | California | MedBasin | Chile | South-Africa | SW Australia | S Australia |
|--------------------|------------|----------|-------|--------------|--------------|-------------|
| Crysmelidae | 1 | 0 | 0 | 0 | 1 | 1 |
| Dryopidae | 1 | 1 | 1 | 1 | 0 | 0 |
| Dytiscidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Elmidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Georriidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Gyrinidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Halplidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Helodidae | 1 | 1 | 0 | 1 | 1 | 0 |
| Helophoridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Heteroceridae | 0 | 0 | 0 | 0 | 1 | 1 |
| Hydraenidae | 1 | 1 | 1 | 1 | 1 | 0 |
| Hydrochidae | 0 | 1 | 0 | 0 | 0 | 1 |
| Hydrophilidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Hygrobiidae | 0 | 1 | 0 | 0 | 0 | 1 |
| Limnebiidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Limnichidae | 1 | 0 | 1 | 1 | 0 | 1 |
| Noteridae | 0 | 1 | 0 | 1 | 0 | 0 |
| Psephenidae | 1 | 0 | 1 | 0 | 0 | 1 |
| Scirtidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Staphylinidae | 0 | 0 | 0 | 0 | 1 | 1 |
| HETEROPTERA | | | | | | |
| Aphelocheiridae | 0 | 1 | 0 | 0 | 0 | 0 |
| Belastomatidae | 1 | 0 | 1 | 1 | 0 | 1 |
| Corixidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Gerridae | 1 | 1 | 1 | 1 | 1 | 1 |
| Hebridae | 1 | 1 | 0 | 1 | 1 | 1 |
| Hydrometridae | 1 | 1 | 0 | 1 | 1 | 1 |
| Naucoridae | 1 | 1 | 0 | 1 | 1 | 1 |
| Nepidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Notonectidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Ochteridae | 0 | 0 | 0 | 0 | 0 | 1 |
| Pleidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Saldidae | 1 | 0 | 0 | 0 | 0 | 1 |
| Veliidae | 1 | 1 | 0 | 1 | 1 | 1 |
| ODONATA | | | | | | |
| Aeshnidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Calopterygidae | 1 | 1 | 1 | 0 | 0 | 0 |
| Chlorophyidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Chorolestidae | 0 | 0 | 0 | 1 | 0 | 1 |
| Coenagrionidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Cordulegasteridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Corduliidae | 0 | 1 | 1 | 1 | 1 | 1 |
| Gomphidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Hemicorduliidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Lestidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Libellulidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Megapodagrionidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Petaluridae | 0 | 0 | 1 | 0 | 1 | 0 |
| Platycnemididae | 0 | 1 | 0 | 1 | 0 | 0 |
| Protoneuridae | 0 | 0 | 0 | 1 | 0 | 1 |
| Synthemidae | 0 | 0 | 0 | 0 | 1 | 1 |
| Telephlebiidae | 0 | 0 | 0 | 0 | 0 | 1 |
| TRICHOPTERA | | | | | | |
| Atriplectididae | 0 | 0 | 0 | 0 | 1 | 1 |
| Beraeidae | 0 | 1 | 0 | 0 | 0 | 0 |
| Brachycentridae | 1 | 1 | 0 | 0 | 0 | 0 |
| Calamoceratidae | 1 | 1 | 1 | 0 | 0 | 1 |
| Conoesucidae | 0 | 0 | 0 | 0 | 0 | 1 |

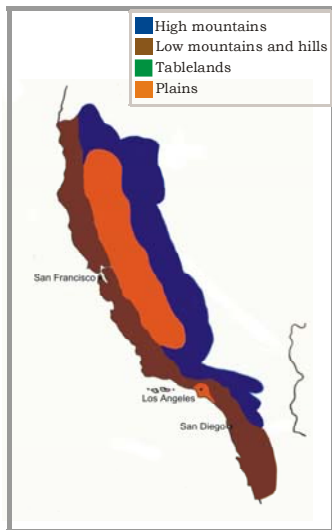
| | California | MedBasin | Chile | South-Africa | SW Australia | S Australia |
|-------------------|------------|----------|-------|--------------|--------------|-------------|
| Dipseudopsidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Ecnomidae | 0 | 1 | 1 | 1 | 1 | 1 |
| Glossosomatidae | 1 | 1 | 1 | 1 | 0 | 1 |
| Goeridae | 1 | 1 | 0 | 1 | 0 | 0 |
| Helicophidae | 0 | 0 | 1 | 0 | 0 | 1 |
| Helicopsychidae | 1 | 0 | 1 | 0 | 0 | 1 |
| Hydrobiosidae | 0 | 0 | 1 | 0 | 1 | 1 |
| Hydropsychidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Hydroptilidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Hydrosalpingidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Lepidostomatidae | 1 | 1 | 0 | 1 | 0 | 0 |
| Leptoceridae | 1 | 1 | 1 | 1 | 1 | 1 |
| Limnephilidae | 1 | 1 | 1 | 0 | 0 | 0 |
| Molanidae | 0 | 0 | 1 | 0 | 0 | 0 |
| Odontoceridae | 1 | 1 | 1 | 0 | 0 | 1 |
| Petrothrincidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Philopotamidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Philorheithridae | 0 | 0 | 0 | 0 | 1 | 1 |
| Pisuliidae | 0 | 0 | 0 | 1 | 0 | 0 |
| Plectrotarsidae | 0 | 0 | 0 | 0 | 1 | 0 |
| Polycentropodidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Psychomyiidae | 1 | 1 | 1 | 0 | 0 | 0 |
| Rhyacophilidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Sericostomatidae | 1 | 1 | 1 | 1 | 0 | 0 |
| Tasimiidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Uenoidae | 1 | 1 | 0 | 0 | 0 | 0 |
| Barbarochtharidae | 0 | 0 | 0 | 1 | 0 | 0 |
| DIPTERA | | | | | | |
| Anthomyiidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Athericidae | 1 | 1 | 1 | 1 | 1 | 0 |
| Blephariceridae | 1 | 1 | 1 | 1 | 0 | 0 |
| Ceratopogonidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Chironomidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Culicidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Dixidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Dolichopodidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Empididae | 1 | 1 | 1 | 1 | 1 | 1 |
| Ephydriidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Limoniidae | 1 | 1 | 1 | 0 | 1 | 0 |
| Psychodidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Ptycopteridae | 0 | 1 | 1 | 1 | 0 | 0 |
| Scatopsidae | 0 | 0 | 0 | 0 | 0 | 1 |
| Sciomyzidae | 1 | 1 | 0 | 1 | 1 | 1 |
| Simuliidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Stratiomyidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Syrphidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Tabanidae | 1 | 1 | 1 | 1 | 1 | 1 |
| Tanyderidae | 0 | 0 | 1 | 1 | 0 | 0 |
| Thaumaleidae | 1 | 1 | 0 | 0 | 1 | 1 |
| Tipulidae | 1 | 1 | 1 | 1 | 1 | 1 |

Plate 1. Characteristics of the mediterranean region in California.



Climatic features

Location and latitude in almost all California, south of Oregon and north of Mexico (1), 28-44°N (2).
Extension of med-region around 250.000 km² (2)
Rank of precipitation from 150mm/y to 1800mm/y (1) with snow in the high mountains of Sierra Nevada.
Months with highest rain between November and March (3).
Range of altitude between 0 to >4000m.
Population of 27.000.000 inhabitants (4)



Basin characteristics

Geology composed by metamorphosed, granites and sedimentary deposits (2).
Landscape and topography composed by Coast, Transverse and Peninsula ranges, Great or Central Valley and a more alpine area in western side of Sierra Nevada, Klamath and Cascade mountains (5&6). Coastal plains scarce.
Vegetation with coniferous trees and meadows in alpine areas, deciduous trees in wet areas, redwood formation in northern California (*Sequoia sempervirens*) and sclerofillous and evergreen trees and shrubs (called “chaparral”), savannas or dry steppe in drier areas (2&4).

Abiotic river properties

Annual discharge peak in winter but also in spring in nival influenced rivers (7). Discharge can be affected by El Niño event (8).
Physical and Chemical properties: oligotrophic rivers with high pH (9).
River and stream typologies: short and steepe streams and rivers from coastal ranges longer, steepeness and wider from inland mountains; karstic rivers in southern California (8).
Riverbed substrate composed by boulders, cobbles, gravels in headwaters and sands and silt downstream. Some bedrock rivers in southern California (10&11).

Biotic river properties

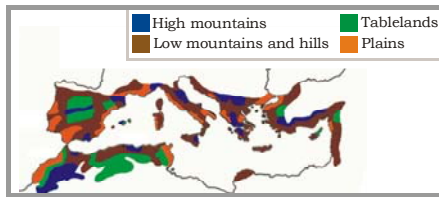
Periphyton community highly diverse, abundant and productive.
Macroinvertebrate community highly diverse but lacks of families present in other areas of North America. Some non-native macroinvertebrate’s families as Corbiculiidae and Grapsidae.
Fish community is highly endemic with 115 taxa (12) closer to European fish fauna than to that of eastern North America (12). Several non-native species are present as *Gambusia affinis*, *G. holbrooki*, *Micropterus salmoides*, *Alosa sapidissima*, *Lepomis macchirus*,... (12&14).
Alloctonous material reach riverbed in autumn, although in undisturbed areas where riparian vegetation unable to survive, sclerofillous leaves arrive to the river along the year (9). Higher decomposition rates in deciduous leaves (15).
Riparian Vegetation mainly with deciduous trees and shrubs (16) as *Salix sp.*, *Alnus sp.*, *Corylus cornuta*, *Populus sp.* or *Fraxinus sp.* Highly altered by non-native species introductions as *Arundo donax*, *Nicotiana sp.*, or *Tamarix sp.*

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Plate 2. Characteristics of the mediterranean region in Mediterranean Basin.



Climatic features

Location and latitude in Mediterranean Sea basin excluding Black Sea, Caspian Sea and Persian Gulf (1), 31-45°N (2).
Extension of med-region around 1.100.000 km² (2)
Rank of precipitation from <300mm/y to 2500mm/y (3) with snow in the high mountains
Months with highest rain between December and January in Southern Europe and in October through the north. A second peak in spring is also present (2)
Range of altitude between 0 to 3500m (2)
Population of 150.000.000 inhabitants (4)

Basin characteristics

Geology mainly with limestone (5) but some metamorphosed, granites and sedimentary deposits (2).
Landscape and topography composed by high mountains (Alpes, Apennines, Balkans, Pyrenees, Iberian and Baetic Cordilleras, Taurus Mountains, Cedres, Atlas, Rif and Kabylie Mountains) and lower hills and mountains sometimes separated by tablelands. Coastal plains frequent.
Vegetation with coniferous trees in alpine areas, deciduous trees in wet areas, sclerophyllous and evergreen trees and shrubs (called "maquia" and "garrigue"), savannas or dry steppe in drier areas (2).

Abiotic river properties

Annual discharge peak. Two annual peaks, in spring and autumn (6 & 22).
Physical and Chemical properties: in siliceous rivers and streams, neutral pH and oligotrophic waters (7), whereas in more calcareous areas higher pH and less oligotrophic waters (8). High natural salinity (by sulphates and chloride) in some semiarid areas (9,10&11).
River and stream typologies: short and steeper streams from coastal ranges longer and wider rivers from inland mountains; karstic rivers frequent (12&13); highly ephemeral rivers called "oueds", "ramblas", "wadis", "torrents" or "barrancos" (14). Some deltas plains are present as in Po, Rhône, Ebre rivers.
Riverbed substrate composed by boulders, cobbles, gravels and bedrock in headwaters and sands and silt downstream.

Biotic river properties

Periphyton community highly diverse, abundant and productive.
Macroinvertebrate community highly diverse (15) and abundant in European area compare with African one (6&16), although a high endemism is present in both regions (6&17). Northern rivers and streams dominated by EPT communities whereas more Ephemeroptera and Coleoptera are present increasing aridity through the south (18). Some non-native macroinvertebrate species as *Procambarus clarkii* and *Potamopyrgus jenkinsii*.
Fish community highly diverse, endemic (80% of the exclusive freshwater species) compared with the rest of Europe (19). Several non-native species are present as *Oncorhynchus mykiss*, *Micropterus salmoides*, *Esox lucius*, *Carassius auratus*, *Cyprinus carpio*, *Gambusia holbrooki*, *Alburnus alburnus*, *Hucho hucho*, *Cichlasoma facetum* and others (19)
Alloctonus material reach riverbed in autumn with a second peak between January and April (20), although in undisturbed areas where riparian vegetation unable to survive, sclerophyllous leaves arrive to the river along the year. Higher decomposition rates in deciduous leaves compared with sclerophyllous ones (21).
Riparian Vegetation mainly with deciduous trees and shrubs as *Salix* sp., *Alnus glutinosa*, *Ulmus* sp., *Corylus avellana*, *Populus* sp., *Fraxinus* sp or *Tamarix* sp. Highly altered by non-native species introductions as *Arundo donax*, *Nicotiana* sp., *Robinia pseudoacacia*, *Platanus hispanica* or *Ailanthus altissima*.

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- | | |
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Plate 3. Characteristics of the mediterranean region in Chile.

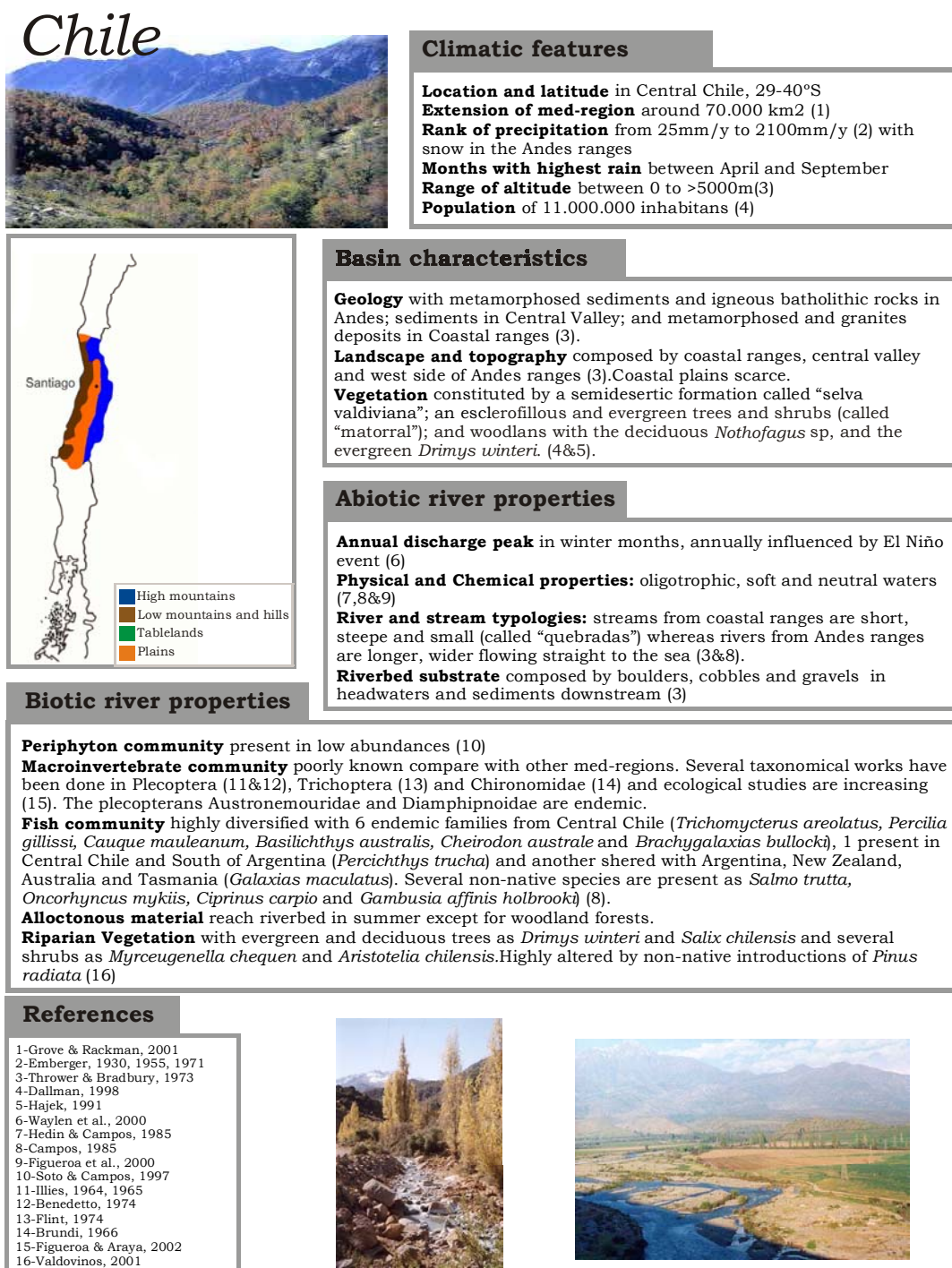
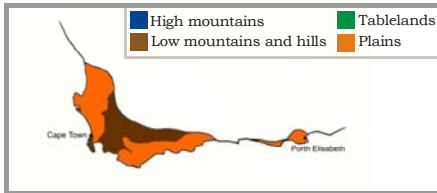


Plate 4. Characteristics of the mediterranean region in South Africa.



Climatic features

Location and latitude in South-western Cape, 32-35°S.
Extension of med-region around 40.000 km² (1).
Rank of precipitation from 230mm/y to >2500mm/y (2) with snow unfrquent.
Months with highest rain between April and September
Range of altitude between 0 to 2300m (3).
Population of 3.400.000 inhabitants (4).

Basin characteristics

Geology with sandstones and shales (3) with acidic and low in nutrients soils (5).
Landscape and topography composed by plains and coastal (Table Mountain) and inland ranges (Franschoek and Drakenstein Mountains) separated from the Cretaceous (6).
Vegetation dominated by fynbos biome (7&8) with evergreen and sclerofilous shrubs highly endemic (9) and divided in mountain and coastal fynbos, coastal renosterveld and strandveld (7).

Abiotic river properties

Annual discharge peak in winter months.
Physical and Chemical properties: acid and oligotrophic headwaters (10) with brown colour (11), but clearer, higher in nutrients and pH downstream (10).
River and stream typologies: c
Riverbed substrate composed by boulders, bedrock, cobbles and gravels in headwaters and stones, pebbles and coarse sand downstream (13).

Biotic river properties

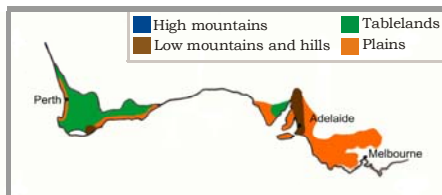
Periphyton community scarce (14) with some macrophytes abundant.
Macroinvertebrate community highly endemic with Gondwanic origin (15&16) but lower in diversity compare with other South African rivers. Presence of taxa adapted to a low fish diversity and abundance (16).
Fish community low in diversity and abundance with some non-native species as *Salmo trutta*, *Tilapia* sp., *Lepomis macrochinus*, *Ciprinus carpio*, *Micropterus dolomieu* and *Micropterus salmoides* (17&18).
Alloctonous material reach riverbed in summer. Low decomposition rate (10&14).
Riparian Vegetation shrubby with *Prionium serratum*, *Metrosideros angustifolia* and *Brabejum stellatifolium*. Non-native species as *Acacia melanoxyton*, *Quercus robur*, *Eucalyptus* sp. and *Hakea* sp. are present (19&20).

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Plate 5. Characteristics of the mediterranean region in Australia.



Climatic features

Location and latitude in South-Western Australia (WA) and South Australia (SA and NSW) (1,2&3) disconnected by 1000km, 28-37°S (4).
Extension of med-region around 350.000 km² (4)
Rank of precipitation from 300mm/y to 1400mm/y (5&6) without snow.
Months with highest rain between April and November.
Range of altitude between 0 to 582m in SW-Australia (7) and to 1300m in S-Australia (8).
Population of 3.000.000 inhabitants (9)

Basin characteristics

Geology composed by sandstones and granites, quartzites and sedimentary deposits (8).
Landscape and topography with a soft relief in SW-Australia with coastal plains an inland plateaus (Darling Plateau) and more abrupt in S-Australia with Flinders Ranges (7).
Vegetation with by sclerophyllous and evergreen shrubs and trees in the coast (called "health" and "mallee"), and Jarrah and Marri forest in the inland plateau in SW-Australia, with *Eucalyptus diversicolor* and *E. marginata* as dominant species (9) . Highly endemic (10).

Abiotic river properties

Annual discharge peak in winter months between June and November (11).
Physical and Chemical properties: oligotrophic rivers with slightly low pH (11).
River and stream typologies: slightly steep rivers in S-Australia coming from Flinger Ranges but steepness streams in SW-Australia flowing from the Darling Plateau to the coast. A big river system "Murray-Darling River" present in S-Australia.
Riverbed substrate composed by gravel and sand with some large rocks (2)

Biotic river properties

Periphyton community scarce and slightly productive (12)
Macroinvertebrate community depauperate in SW-Australia respect S-Australia (2,12&13). Some Gondwanic relicts as some species of the crayfishes *Cherax* sp. and *Engaewa* sp. (14).
Fish community highly diverse in the Murray-Darling river system. In South Western Australia the community is dominated by *Galaxias occidentalis*, *Bostockia porosa* and the endemic *Edelia vittata*. Several non-native species are present as *Oncorhynchus mykiss*, *Gambusia holbrooki* and *Perca fluviatilis*
Alloctonous material reach riverbed in summer (15&16). Few shredders to process CPOM (17).
Riparian Vegetation mainly sclerophyllous trees and shrubs as *Dodonea* sp., *Banksia* sp., *Hakea* sp., *Trymalium floribundum*, *Melaleuca* sp., *Callitris* sp. *Angianthus* sp., *Eragrostis* sp., and several *Eucalyptus* sp. Altered by non-native introductions of *Pinus* rsp *Mimosa pigra* are common (18).

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