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Ecological distribution of Coleoptera in an Algerian river system: the Sebaou (Tizi-Ouzou, Algeria) [Coleoptera]

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Aquatic beetles were collected between 1986 and 2001 in the Sebaou wadi river system. Larvae and adults were collected from 12 samplings stations located between 20 and 920 m above sea level that encompass a wide variety of aquatic habitats. 83 species belonging to 39 genera and 11 families could be identified. This faunistic list has enriched the fauna of Algeria by seven species previously unknown: *Hydroporus tristis* (Paykull, 1798), *Ochthebius* (*Ochthebius*) *pedicularius pedicularius* Kuwert, 1887, *Chaetarthria seminulum* (Herbst, 1797), *Cymbiodyta marginella* (Fabricius, 1792), *Coelostoma* (*Coelostoma*) *hispanicum* (Küster, 1848), *Hydroscapha granulum* (Motschulsky, 1855), *Dryops nitidulus* (Heer, 1841). These beetle communities are dominated by Mediterranean elements, with a high level of endemic species (16, 66%).

Distribution écologique des Coléoptères d'un réseau hydrographique algérien : le Sébaou (Tizi-Ouzou, Algérie) [Coleoptera].

Mots clés : Coléoptères aquatiques, écologie, biogéographie, Kabylie, Algérie.

Des coléoptères aquatiques ont été récoltés entre 1986 et 2001 dans le réseau hydrographique du Sébaou. Des larves et des adultes ont été récoltés dans 12 stations entre 20 et 920 m d'altitude qui regroupent une grande variété d'habitats aquatiques. 83 espèces réparties en 39 genres et 11 familles ont pu être recensées. Cet inventaire a enrichi la faune d'Algérie de sept espèces nouvellement citées : *Hydroporus tristis* (Paykull, 1798), *Ochthebius* (*Ochthebius*) *pedicularius pedicularius* Kuwert, 1887, *Chaetarthria seminulum* (Herbst, 1797), *Cymbiodyta marginella* (Fabricius, 1792), *Coelostoma* (*Coelostoma*) *hispanicum* (Küster, 1848), *Hydroscapha granulum* (Motschulsky, 1855), *Dryops nitidulus* (Heer, 1841). Ce peuplement est dominé par les éléments à distribution méditerranéenne avec une proportion relativement élevée d'endémiques (16,66 %).

1. Introduction

The first works devoted to the aquatic beetles of North Africa in general, and Algeria in particular, are very old since Bedel published a first catalogue in 1895. Subsequent references are: REICHE (1872), PIC (1905), PEYERIMHOFF (1905, 1925), GAUTHIER (1928), NORMAND (1933) and

MASSON (1939) and, in the second half of the 20th century, GUIGNOT (1959) and BERTHÉLEMY (1964). Additional information on this group of insects is then added through recently published catalogs in the Palearctic area (LÖBL & LÖBL, 2015, 2016, and 2017).

More recently, as part of studies on the fauna of lotic macroinvertebrates in northern Algeria, the harvests carried out by various authors have contributed to a better knowledge of this order of insects (BERTHÉLEMY et al. 1991, LOUNACI-DAOUDI 1996, LOUNACI et al. 2000, MEBARKI 2001, LOUNACI 2005, INCEKARA 2007, INCEKARA & BOUZID 2007, INCEKARA et al. 2007, BOUKLI-HACENE et al. 2012, MATALLAH et al. 2016, FERY 2016, FERY & BOUZID 2016, LAMINE et al. 2019, LAMINE 2021).

The aim of this work is to increase the inventory of the species present, contributing to a better knowledge of their ecology and geographical distribution, and on the other hand to allow a comparison with the fauna of other regions of the Mediterranean basin.

2. Material and methods

2.1. Study area

The studied area is located about 100 km east of Algiers. It extends from the peaks of the Djurdjura massif (Tizi-Ouzou) (Alt. max.: 2308 m) to the Mediterranean Sea. Our study focused on the Sebaou wadi and its main tributary, the Aïssi wadi.

The Sebaou wadi, main watercourse of Great-Kabylia, originates east of the Djurdjura range and reaches the sea after a course of about 100 km. Its upper part (the upper Sebaou) has an average slope of the order of 2% and flows from south to north over a distance of 30 km between 500 and 150 m of altitude. Its lower part is 70 km long and with a relatively flat and wide bed (average slope of the order of 0.5%), flows in an east-west direction for a distance of 50 km, then from south to north for about twenty km before falling into the Mediterranean Sea. On its course are important sand pits inducing, by the extraction of aggregates, disturbances of the environment. The river also receives urban discharges, particularly from the cities of Tizi-Ouzou and Draâ-Ben-Khedda, and industries (textiles, milk and derivatives, wood and derivatives, household appliances, etc.).

The Aïssi wadi, the main tributary of the Sebaou wadi, takes its source in the median ridge of the Djurdjura. It flows in south-north orientation between 100 and 1100 m elevation over a distance of 50 km until its confluence with the wadi Sébaou. This tributary has, in its upstream part, a slope of the order of 10% inducing a torrential hydrological regime and, in its downstream part, an average slope of the order of 1%.

The climate in this region is Mediterranean: hot, dry summers and cold, rainy winters (CHAUMONT & PAQUIN 1971). In the Djurdjura massif (alt. >1000 m), average annual precipitation is around 1200 mm (DERRIDJ 1990). In the Sebaou valley, they are of the order of 700 mm (LOUNACI 2005). Many rivers dry out from June to November. In winter, stormwater runoff can cause short and violent floods that strongly disturb lotic environments.

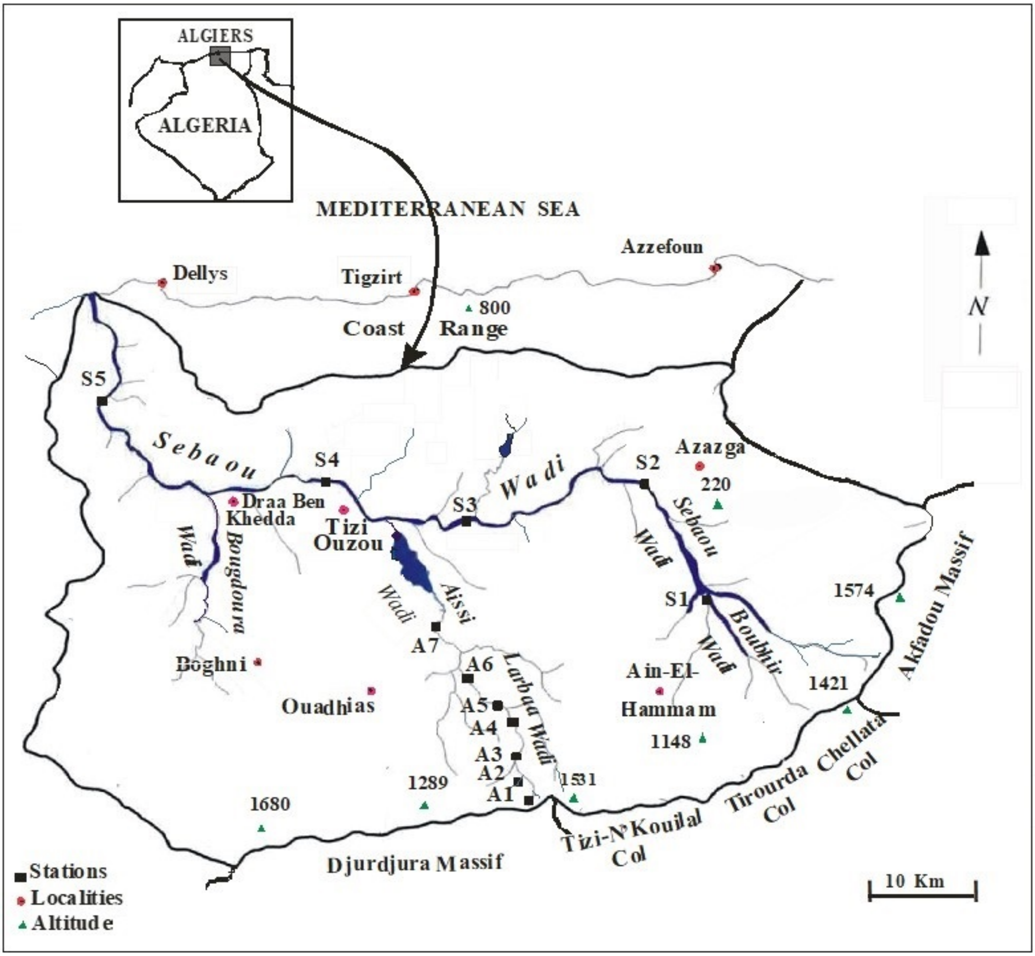

Figure 1. Geographic location of the water courses studied and the 12 sampling stations.

Figure 1. Localisation géographique des cours d'eau étudiés et des 12 stations d'échantillonnage.

2.2. Study sites and methods

Twelve stations were selected on the axial course of the rivers and appear to us to reflect the diversity of habitats and cover a wide range of mesological situations (Fig. 1): Aïssi wadi seven, Sebaou wadi five.

Biological material was obtained from benthic samples with a Surber net (0.3 mm mesh vacuum conforming to international standard ISO 8265; area sampled 1/10 m^2). Collecting was spread over about 15 years (1986-2001) with an average of five harvests per year. As far as possible, we surveyed the largest number of stations at the same time: in spring and early summer (March, April, May, June and July), which appeared to be the most favourable period for the development of benthic fauna.

For each station, we give: A= altitude in m, P= slope in %, D= distance to source in km, L= width of minor bed in m, H= height of water in cm, V= speed of current, T= temperature of water in °C (minima-maxima), S= substrat.

Sebaou wadi:

S1 : A 220, P 2.5, D 25, L 2, H 30, V medium to fast, T 9-30, S pebbles, sand, seaweeds, organic matter.

S2 : A 160, P 1.2, D 40, L 5, H 20, V medium to fast, T 11-30, S pebbles, sand, macrophytes, seaweeds, organic matter.

S3 : A 100, P 0.2, D 45, L 10, H 30, V slow to medium, T 11-32, S pebbles, sand, macrophytes, seaweeds, organic matter.

S4 : A 60, P 0.6, D 75, L 15, H 30, V slow to medium, T 12-33, S pebbles, sand, macrophytes, seaweeds, matières organiques.

S5 : A 20, P 0.5, D 90, L 20, H 20, V slow to medium, T 13-33, S pebbles, sand, macrophytes, seaweeds, organic matter.

Aïssi wadi:

A1 : A 920, P 10, D 0.5, L 1, H 20, V fast to very fast, T 8-14, S rocks, boulders, gravel.

A2 : A 810, P 10, D 1, L 0.5, H 10, V medium to fast, T 10-16, S rocks, boulders, organic waste.

A3 : A 480, P 10, D 3, L 1.5, H 20, V medium to fast, T 9-16, S boulders, pebbles, plant debris.

A4 : A 380, P 2.5, D 4.5, L 4 , H 30, V medium to fast, T 11-28, S pebbles, sand, seaweeds, plant debris.

A5 : A 300, P 1.5, D 11, L 5, H 30, V medium to fast, T 11-27, S pebbles, sand, seaweeds, plant debris, organic matter.

A6 : A 200, P 1.4, D 20, L 8, H 30, V medium to fast, T 11-27, S pebbles, sand, seaweeds, plant debris, organic matter.

A7 : A 140, P 0.8, D 30, L 10, H 30, V slow to medium, T 11-31, S pebbles, sand, seaweeds, plant debris, organic matter.

As for the identification of the biological material harvested, we have chosen initially to determine at best the fauna up to the family or the genus taxonomic level, according to the identification keys available (BERTRAND 1972, GENTILI & CHIESA 1975, FRANCISCOLO 1979, BERTHÉLEMY 1979, TACHET et al. 1980, RICHOUX 1982, TACHET et al. 2000), then we called upon specialists for further determinations (A. Kaddouri and P. Richoux: families of Hydraenidae and Elmidae, J. Moubayed, P. Richoux and A. Nelsson; the other families of beetles).

3. Results

The order of beetles is well represented in the studied river system: 83 taxa belonging to 39 genera and 11 families have been recorded. 66 taxa could be identified at the specific level and 17 at the generic level (Table 1 in appendix pp 61-62). Seven species are mentioned for the first time in Algeria: *Hydroporus tristis, Ochthebius* (*O.*) *pedicularius pedicularius, Chaetarthria seminulum, Cymbiodyta marginella, Coelostoma* (*Coelostoma*) *hispanicum, Hydroscapha granulum* and *Dryops nitidulus.*

Qualitatively, the families of Dytiscidae, Hydrophilidae and Hydraenidae are the best represented, their group in themselves contains 52 species (62.65% of the total), divided into 23 genera (Dytiscidae 12 genera, 20 species, Hydrophilidae eight genera, 17 species, Hydraenidae three genera, 15 species), then come the Elmidae with six genera, 11 species. Other families are weakly represented, with only one, two or three genera (Table 2).

Families	Genera number	Taxa number	Number of species identified	Sp. number
Hydrophilidae	8	17	15	2
Dytiscidae	12	20	18	2
Hydraenidae	3	15	11	4
Elmidae	6	11	9	2
Helodidae	3	4	0	4
Dryopidae	1	5	5	0
Haliplidae	2	4	3	1
Hydrochidae	1	2	2	0
Helophoridae	1	2	2	0
Hydroscaphidae	1	2	1	1
Gyrinidae	1	1	0	1
Totals	39	83	66	17

Table 2. Specific richness per family.

Tableau 2. Richesse spécifique par famille.

The distribution of the beetles in the various stations studied (Fig. 2) highlights their importance in the piedmont and low altitude areas (140-500 m) where 74 taxa were recorded, mostly in medium current and at relatively high temperature. In the upper zones of the rivers, above 800 m elevation, and in the lowland environments (alt. 20-100 m), the species richness is noticeably lower, with respectively 29 and 18 species.

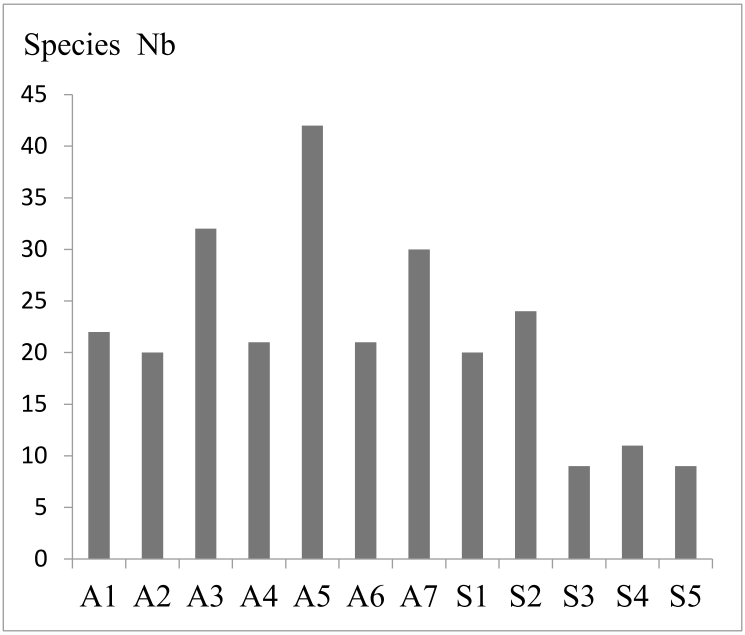

Figure 2. Specific richness of Coleoptera in the studied stations.

Figure 2. Richesse spécifique des Coléoptères aux stations étudiées.

The highest species richness (42 species) is observed at station A5 (alt. 300 m) and, to a lesser degree, at stations A3 and A7 (32 and 30 species respectively). At these stations, characterized by an moderate current, the thermophilic species characteristic of low-altitude biotopes are encountered with other elements rising upwards, escaping the excessive temperature rises of plain rivers, as well as elements of wide ecological valence.

The altitude stations above 800 m, with cool water (stations A1, A2) and shaded, host a relatively little diversified fauna: 22 and 20 species, mostly rhithrophilic and cold water stenotherms.

As for the plain stations, S3, S4, S5, they host a 'poor' fauna: respectively nine, eleven and nine species. This sector is characterized by the disappearance of most taxa from the upper parts of rivers and by the presence of only eurytherm and polluto-resistant species.

3.1. Wildlife and ecological data

Beetles are a highly diverse and ecologically heterogeneous group that can adapt to many biotopes. Some families have representatives whose only larval phase is aquatic (Helodidae) (BERTRAND 1972) or on the contrary whose only adult phase lives in open water (Hydraenidae) (BERTHÉLEMY 1966, JÄCH 1984).

3.1.1. Sub-Order Adephaga Schellenberg, 1806

Hydrocanthares are aquatic for almost their entire life cycle, their nymphs alone being terrestrial. They live in a wide variety of environments (lotic and slow environments), with a preference for calm or low-current waters, rich in vegetation (BERTRAND 1972).

Family Gyrinidae Latreille, 1810

Most Gyrinidae colonize calm waters. They generally inhabit stagnant or very slow-flowing waters along the edges of rivers (BERTRAND 1972, FRANCISCOLO 1979). In the streams studied, Gyrinidae are represented by only one taxa: *Gyrinus* sp. and two individuals from station A7 (alt. 140 m).

Family Haliplidae Aubé, 1836

Four species belong to the genera *Peltodytes* and *Haliplus*, the most frequent and abundant being *P. rotundatus* and *H. lineatocollis*. The first species is thermophilic and limnophilic. It is widespread in low-lying and plain (20-220 m) streams with lentic facies, rich in aquatic vegetation (macrophytes and algae) and slow current on a substratum with fine granulometry (sand, silt and mud). The second species frequents rather the piedmont and low-lying environments (140-380 m); it seems to avoid the plain waters with high thermal amplitude.

The other two species, rare in our samples, were collected at a single station: *P. caesus caesus* in A5 (alt. 300 m) and *Haliplus* sp. in A4 (380 m).

Family Dytiscidae Leach, 1815

The Dytiscidae represent one of the most diverse families of beetles in our samples: 20 species in 12 genera.

With six species, *Hydroporus* is best represented. The other genera are much less diverse.

According to BERTRAND (1972) and FRANCISCOLO (1979), the Dytiscides constitute one of the most important groups of aquatic beetles, well homogeneous and distinct from the other

Hydrocanthares. They live mainly in calm or low-current waters, on a substratum with fine grain size, supporting more or less important aquatic vegetation. Some species can tolerate medium to fast current lotic environments on gravel-dominated substrate.

The subfamily Laccophilinae is very poorly represented: two species, *Laccophilus minutus* and *L. hyalinus*, localized (stations A4, A5 and S1) and always in small numbers.

According to GUIGNOT (1931, 1933) and FRANCISCOLO (1979), the *Laccophilus* species are eurytherm and eurytope, encountered in many common and stagnant environments and sometimes reaching a significant altitude.

The Hydroporinae are the most diverse subfamily of beetles of our samples: 18 species in 11 genera. With six species, *Hydroporus* is best represented. The other genera are much less diverse: *Bidessus* (two species), *Graptodytes* (two species), *Deronectes* (one), *Hydrovatus* (one), *Yola* (one), *Hygrotus* (one), *Nebrioporus* (one), *Rhithrodytes* (one), *Scarodytes* (one) and *Stictonectes* (one).

Eurytherms, *Bidessus minutissimus minutissimus* and *Nebrioporus clarkii* are the dominant Hydroporinae species, the first encountered whithin ten stations, the second whithin five. They are particularly abundant in low altitude environments (160-220 m), high summer warming of water with proliferation of macrophytes.

Hydroporus pubescens and *H. tristis* are frequent (seven stations staggered between 140 and 920 m of altitude) but not abundant. They are found in medium-high and low-lying rivers. Their absence in the lower lowland stations may be due to the high summer temperature and the impact of human actions.

The presence of other Hydroporinae appears sporadic. They are highly localized and collected in very low numbers. They can potentially characterize a portion of the waterways. These elements can be divided into two ecologically distinct groups:

- *Hydroporus tessellatus tessellatus*, *Rhithrodytes sexguttatus*, *Graptodytes varius* and *Stictonectes escheri* appear to be related to mid-mountain shaded biotopes (alt. 480-920 m), with medium current, stony bottom and relatively cool water (8-16°C). They may be considered to prefer upper parts of rivers. The average mountain seems to correspond to their lower limit of distribution.

- *Yola bicarinata*, *Bidessus coxalis*, *Hydroporus planus*, *Hygrotus inaequalis*, *Graptodytes fractus fractus*, *Scarodytes halensis halensis* and *Deronectes fairmairei* would have low-level biotopes (140-380 m) as habitat. These species appear hemistenotherms and their distribution is limited, confined to a single section of streams. The change in natural conditions during the transition to the plain (excessive temperature rise, anthropogenic actions) seems unfavourable to their development.

3.1.2. Sub-Order Polyphaga Emery, 1886

Polyphaga inhabit aquatic environments of varied nature, both stagnant and current water. However, running water is the area most frequently used by most families, including Hydraenidae, Dryopidae and Elmidae (RIBERA & VOGLER 2000).

Family Hydraenidae Mulsant, 1844

Unlike the predominantly limnophilic Hydrocanthares, Hydraenidae are generally rheophilic, inhabiting both cold and warm lowland and plain facies (JÄCH 1995, LAMINE et al. 2019).

The prevalence of Hydraeninae hydraenini at high altitude has already been shown by BERTHÉLEMY (1966). Here, this tribe is represented by five species, three of which: *Hydraena mouzaïensis*, *H. pici* and *H. cordata*, have a marked preference for spring creeks and medium mountain shaded courses. They are rheophilic and cold water stenotherm. The two first are frequent and abundant; the third is rather rare, encountered at the only station A2 (810 m).

The other two species, *H. numidica* and *H. rivularis*, are rather eurytherm with a broad ecological valence. They are common and occur along rivers. However, the former predominates clearly in the medium-mountainous shaded areas (stations A2 and A3), the latter in the low-altitude areas (S1 and S2).

The tribe of Limnebiini is represented by three species of the same genus: *Limnebius evanescens*, *Limnebius* sp. 1 and *Limnebius* sp. 2, showing a certain complementarity in their distribution.

Limnebius evanescens and *Limnebius* sp. 2, thermophile, are collected mainly at low altitude (60-220 m), where they frequent the bottom rich in fine sediments and filamentous algae. The third (*Limnebius* sp. 1), the most alticolous, has a wide ecological valence. It is present at five stations, between 140 and 920 m. Its highest population density is observed at station A3 (480 m), shaded and with relatively cool water (T° 9-16 °C).

The subfamily Ochthebiinae is represented by seven species of which *Ochthebius (Ochthebius) pedicularius pedicularius* is a new citation for Algeria. According to JÄCH (1984), *Ochthebius* are generally rheophilic but with some limnophilic-tended representatives.

In Kabylia, most *Ochthebius* are scarce and infrequent. Of the seven elements encountered, only *Ochthebius* (*Ochthebius*) sp. 1 can be considered as a cold water beetle and stenotherm, with a strong preference for the upper parts of rivers. It is related to shady, cool water lotic habitats on coarse mineral substrate (large pebbles, gravel), partially covered with plant debris.

Ochthebius (*O.*) sp. 2 is less alticole and more thermophilic than previous species. It was collected at four stations at an altitude of 140 to 810 m.

Ochthebius (*O.*) *semisericeus* is relatively abundant in our collecting. Its distribution is limited to warm low-lying and plain biotopes (alt. 60-220 m) with or without slow macrophytes.

The sample of other *Ochthebius* species (*Ochthebius* (*O.*) *difficilis*, *Ochthebius* (*O.*) *lobicollis*, *Ochthebius* (*O.*) *pedicularius pedicularius* and *Ochthebius* (*Asiobates*) *dilatatus*) was too fragmentary to interpret their distribution along the study streams.

Families Helophoridae Leach, 1815 and Hydrochidae Thomson, 1859

Helophoridae and Hydrochidae are monogeneric families, each with a single genus, *Helophorus* and *Hydrochus*, respectively (MART et al. 2010, HANSEN 1991, JÄCH & BALKE 2008). They usually live in stagnant water. Most of their representatives colonize the pools and dead arms of the rivers (BERTRAND 1972, ANGUS 1973). Some elements, such as *Helophorus*, can live at high altitude.

These two families are poorly represented in the rivers of Kabylia. There are four species: two Helophoridae and two Hydrochidae.

The genus *Helophorus* colonizes mainly shaded biotopes. *Helophorus (Rhopalohelophorus) asturiensis* is collected in a spring stream (alt. 810 m) of small size, fresh water (8 - 16°C), slow flow and substrate of gravel and sand rich in plant debris. The second species, *H. (R.) minutus*, is located at three stations staggered between 300 and 920 m elevation. Its maximum population density is observed at station A3 (380 m).

Hydrochids (*Hydrochus grandicollis*, *H. nitidicollis*) are rare in our samples: two or three individuals collected once from a low-altitude station. They seem to frequent environments with slow facies: very infrequent or stagnant waters (ponds and dead arms).

Family Hydrophilidae Latreille, 1802

Hydrophilidae, after Dytiscidae, rank second in our surveys as to the species numbers. They occupy a wide variety of biotopes, both in lotic and slow habitats.

17 species in eight genera and two subfamilies (Hydrophilinae and Sphaeridiinae) are recorded in our material. The genus *Laccobius*, with seven species, is best represented: the others are monospecific (*Berosus, Chaetarthria, Haemisphaera*, *Cymbiodyta, Coelostoma*) or bispecific (*Paracymus, Anacaena*).

Three species of *Laccobius* are mainly distributed in low-lying and plain environments, rich in organic matter: *L. atrocephalus*, *L. mulsanti* and *L. hispanicus*. Their high abundance can be attributed to the summer warming of the water, the reduction of the flow and the development of aquatic vegetation known by these biotopes, which highlights their lenithophilic and potamobionte character. The four other species (*L. neapolitanus*, *L. praecipuus*, *L. sinuatus sinuatus*, *Laccobius* sp.) are sparsely abundant and are confined to piedmont and low-lying habitats (140 - 380 m).

The genera *Paracymus, Anacaena* and *Haemisphaera* are significantly higher alticolous than *Laccobius*. In the areas surveyed, *Haemisphaera seriatopunctata*, *Paracymus aeneus* and *P. scutellaris* show a preference for medium-sized mountain and piedmont rivers with shady courses. These elements do not seem to withstand the warming of low altitude habitats and disappear rapidly from station A5 (300 m) where the temperature rise is very sensitive.

Anacaena bipustulata and *A. globulus* are most common (> 40%) in the studied network between 140 and 920 m and fairly abundant. They frequent sections of slow water with mixed grain size and rich in plant debris.

The genera *Cymbiodyta*, *Coelostoma* and *Chaetarthria* are represented by a single species each: *Cymbiodyta marginella*, *Coelostoma hispanicum* and *Chaetarthria seminulum*, new quotations for Algeria and poorly known ecology. The two first are rare in our samples, present in habitats of low altitude (station A7) or plain (station S4) rich in bryophytes. The third, *Chaetarthria seminulum*, is rather common but very scarce. We collected it at four stations ranging from 140 to 810 m above sea level.

The genus *Berosus* is also represented by a single species: *B. affinis*. It is rare in our samples: three individuals collected only once, from two stations of low altitude (stations S1 and S3) where it seems to frequent the environments with lentic facies.

Family Hydroscaphidae LeConte, 1874

This is a small group of aquatic beetles, few of which have been described to date. The habitat of representatives of this small family is the ponds and riverbanks (BERTRAND 1972, IENIŞTEA 1978, PIRISINU 1981).

Hydroscapha granulum is a newly inventoried species for Algeria. We collected it at two stations (S2 and S4), in a quiet area, rich in aquatic vegetation.

Hydroscapha sp., different element from *H. granulum*, is quite common but very infrequent. We collected it at low densities at four stations (A3, A5, A6 and A7) between 140 and 480 m elevation in biotopes with heterogeneous bottoms, slow to medium water flow.

Family Helodidae Fleming, 1821

In the imaginal state, the Helodidae frequent the vicinity of the waters, wet or wooded places. In the larval state, however, all are aquatic: ponds, lakes, forest streams (BERTRAND 1972).

The family Helodidae is represented by four taxa: *Helodes* sp.1, *Helodes* sp.2, *Hydrocyphon* sp. and *Prionocyphon* sp., relatively abundant and fairly common in surveyed streams. They are mainly collected in middle mountain and piedmont areas.

Family Dryopidae Billberg, 1820

Dryopidae colonize different types of environments: running and stagnant waters, wet soils. Some are totally aquatic, other ones amphibious, sometimes terrestrial (OLMI 1972, BERTRAND 1972, BERTHÉLEMY & OLMI 1978, JÄCH & BALKE 2008).

Five species belong to a single genus: *Dryops.*

- *D. gracilis* and *D. subincanus* are rare in our samples. The first is collected at two mid-mountain stations (A2, A3) with dense vegetation cover and relatively cool water (9-16°C). The second seems to be more thermophilic. It is noted in three stations between 100 and 220 m elevation, in quiet areas, rich in aquatic vegetation.

- *D. algiricus*, *D. lutulensis* and *D. nitidulus* are fairly abundant. Their distribution appears to be limited to low-level (140-220 m) slow to medium flow biotopes.

Family Elmidae Curtis, 1830

Elmidae are common, abundant and among the most rheophilic beetles. Only a few elements, such as *Oulimnius* and *Esolus*, eurytherm, exhibit a low limnophilic tendency and can colonize infrequent waters (BERTHÉLEMY 1966, THOMAS & BERTHÉLEMY 1991, LOUNACI 2005, LAMINE 2021).

The North African Elmidae show generally larger variations in size than in Europe. This fact is, according to BERTHÉLEMY (1964, 1979), probably related to the wide variety of running water biotopes in Maghreb. Moreover, the autoecology of these species remains little known.

We have chosen this family as a priority for an ecological analysis, because of its specific diversity and the high potential significance of its representatives in lotic environments.

The rivers of Kabylia host 11 species of Elmidae belonging to six genera: *Elmis* (one species), *Esolus* (three), *Limnius* (two), *Normandia* (one), *Oulimnius* (three) and *Stenelmis* (one).

The species richness of this family is relatively important in relation to neighbouring regions: Moyen-Atlas, 13 species (DAKKI 1987); Haut-Atlas, six species (BOUZIDI 1989); Tunisia, six species (BOUMAIZA 1994). However, it remains low compared to that of the rivers of south-west France: 24 species (BERTHÉLEMY 1966, THOMAS & BERTHÉLEMY 1991).

The longitudinal distribution (Fig. 3) shows two essential points already noted by Berthélemy (1966) in the Pyrenees:

- the number of species increases from upstream to downstream. Four species are recorded in the source stream area and ten at low altitudes;

- upstream-downstream species replacements are observed in the genera *Esolus* and *Oulimnius*.

Esolus are well represented, with three species recorded from very distinct biotopes. *E. filum* prefers hemistenotherm streams. It is observed in six stations of the Aïssi wadi and is absent in the Sebaou wadi. The other two, *E. pygmaeus* and *E.* sp. are strictly subservient to low-lying and plain rivers. They are thermophilic and abundant in slow-flowing habitats.

In Middle Europe, HORION (1955) noted the upstream-downstream replacement of three species of *Esolus*: *E. angustatus*, *E. parallelepipedus, E. pygmaeus*. BERTHÉLEMY (1966) and THOMAS & BERTHÉLEMY (1991) observed the same situation in southwest France. In Kabylia, the altitudinal replacement is equally clear: *E. filum* is between 140 and 920 m and *E. pygmaeus* between 20 and 220 m elevation.

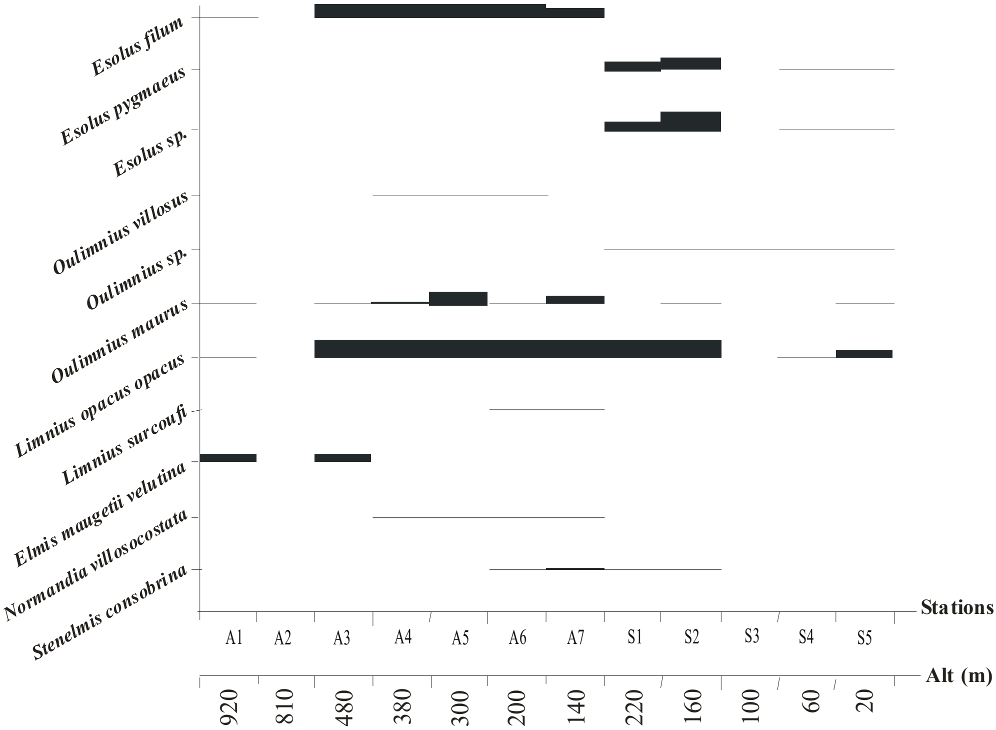

Figure 3. Altitudinal distribution of Elmidae in the water courses of Kabylia.

Figure 3. Répartition altitudinale des Elmidae des cours d'eau de Kabylie.

Species abundance classes (classes d'abondance des espèces) :

1-3 individuals (1-3 individus)
4-10 individuals (4-10 individus)
11-30 individuals (11-30 individus)
31-100 individuals (31-100 individus)
>100 individuals (>100 individus)

The genus *Oulimnius* is represented by three species: *O. maurus*, *O. villosus* and *Oulimnius* sp. *O. maurus* is the most abundant and widely distributed: eight stations between 20 and 920 m of altitude, but it shows a clear preference for low altitude environments (140-380 m).

O. villosus and *Oulimnius* sp. are quite common but very sparse. The first, hemistenotherm, appears in only three stations of altitude between 200 and 380 m, the second descends much more downstream in the plain zone: four stations, between 20 and 220 m. It is eurytherm and prefers habitats with slow current.

The *Limnius* are represented by two species: *L. opacus* and *L. surcoufi*. The first is very common and most often very abundant. It shows a clear eurytopia since it is found on almost all the streams surveyed. *L. surcoufi* is rare in our material, present only at two stations: A6 and A7 (200 and 140 m) in small numbers. Its absence in the plain could be explained in part by an intolerance to high summer thermal conditions and the impact of anthropogenic activities, especially in the lower part of the basin.

Elmis maugetii velutina is strictly confined to mid-mountain habitats with dense bordering vegetation cover, cool water (8-16°C) and fast current, highlighting its rheophilic and cold water stenotherm character.

Normandia villosocostata is quite common but very scanty. It was recorded at four stations ranging from 140 to 380 m above sea level, characterized by an average current and a relatively high temperature (11-28 °C), on gravel-dominated substrate. These observations are similar to those reported in Morocco by DAKKI (1987).

The only known *Stenelmis* in the study area, *Stenelmis consobrina consobrina*, is represented by only a few individuals. It is recorded in four stations, between 140 and 220 m of altitude, in biotopes with slow to medium current, flowing on a bottom of pebbles and sand rich in organic matter.

3.2. Biogeographic overview

Although the aquatic beetles are still relatively unknown in Algeria and neighbouring countries, it is possible, from the existing bibliography, to point out some trends on the geographical distribution of the elements of this group.

The population recorded in this work is largely palearctic, with a Mediterranean character. It is poor in elements of medium and northern Europe and Asia (genera *Peltodytes, Haliplus, Hygrotus, Nebrioporus* and *Hydroporus*) and afro-tropicals (genera *Hydrovatus, Bidessus* and *Laccophilus*). It maintains close relations with the Iberian Peninsula, Italy, Sicily and Sardinia. Indeed, the penetration of species from southern Europe into North Africa probably occurred during geological periods, at the juncture between the two continents: the Gibraltar region, as well as other regions forming part of the Tyrrhenide, a vast continent extending over the present-day Mediterranean between Spain and Italy and from the Rif to the Khroumirie (JEANNEL 1956).

To compare current faunistic data with literature, we have mainly referred to the following works: GAUTHIER (1928), NORMAND (1933), GUIGNOT (1959), BERTHÉLEMY (1964, 1979), ANGUS (1973, 1976), OLMI (1972, 1978), GENTILI & CHIESA (1975), BERTHÉLEMY & OLMI (1978), FRANCISCOLO (1979), PIRISINU (1981), KADDOURI (1986), MOUBAYED (1986), DAKKI (1987), BERTHÉLEMY et al. (1991) and TOUABAY et al. (2002). Only the 66 taxa identified at the specific level have been taken into account and can be classified into four groups.

a- Species with a wide geographic distribution, 25 in number, from North Africa to Middle and Western Europe, to Asia: *Peltodytes caesus caesus, Haliplus lineatocollis, Laccophilus hyalinus, L. minutus, Bidessus minutissimus minutissimus, Hygrotus inaequalis, Hydroporus obsoletus, H. planus, H. pubescens pubescens, H. tristis, Graptodytes varius, Nebrioporus clarki, Ochthebius dilatatus, O. difficilis, Hydrochus grandicollis , H. nitidicollis, Helophorus minutus, Paracymus aeneus, Anacaena bipustulata, Laccobius atrocephalus, L. sinuatus sinuatus, Hydroscapha granulum, Dryops gracilis, D. lutulensis, Stenelmis consobrina consobrina.*

b- The 12 species considered to be circum-Mediterranean, quite widespread in the Mediterranean basin, covering North Africa, Mediterranean Europe and the Near East: *Peltodytes rotundratus, Bidessus coxalis, Hydroporus tessellatus tessellatus, Scarodytes halensis halensis, Deronectes fairmairei, Paracymus scutellaris, Anacaena globulus, Laccobius praecipuus, Dryops algiricus, D. nitidulus, Esolus pygmaeus, Limnius opacus.*

c- Western Mediterranean species, of which there are 18, with a range that extends more or less widely in the western part of the Mediterranean. They cover the Maghreb, the Iberian Peninsula, Southern France and Italy: *Yola bicarinata, Graptodytes fractus fractus, Rhithrodytes sexguttatus, Stictonectes escheri, Hydraena cordata, Ochthebius lobocollis, O. pedicularius pedicularius, O. semisericeus, Helophorus asturiensis, Berosus affinis, Haemisphaera seriatopunctata, Laccobius hispanicus, L. femoralis mulsanti, Cymbiodyta marginella, Chaetarthria seminulum, Limnebius evanescens, Coelostoma hispanicum, Dryops subincanus.*

d- The 11 endemic species of North Africa, distributed as follows:

- *Normandia villosocostata* is endemic to the Maghreb. It is known from Morocco, Algeria and Tunisia.

- *Laccobius neapolitanus, Hydraena numidica, H. rivularis, H. pici* and *Esolus filum* are confined to the eastern edge of North Africa (Algeria, Tunisia);

- *Elmis maugetii velutina* and *Oulimnius villosus* are confined to the western edge of North Africa (Algeria, Morocco);

- *Hydraena mouzaïensis*, *Limnius surcoufi* and *Oulimnius maurus* have a limited distribution in Algeria. They have never been reported outside of this country.

4. Discussion

With the exception of Hydraenidae and Elmidae, the North African aquatic beetles are a poorly studied group with relatively difficult taxonomy and specific determination. The reduced number of species present compared to that of networks in Mediterranean Europe, associated with their high ecological valency and difficulty in comparing the ecology of congeneric species (BERTHÉLEMY 1966), makes the analysis of the results delicate.

This work has enabled the acquisition of interesting data from a systematic, biogeographical and ecological point of view on the aquatic beetles of Algeria. Our study, which focuses on running water, identified 83 taxa, including seven newly listed species. These findings are an important contribution to the knowledge of the North African beetle fauna. The specific richness of this settlement seems to be relatively large compared to that of the other rivers of neighbouring countries. For example, 54 species have been reported in the Middle Atlas Tizguit wadi (TOUABAY et al. 2002).

Several authors have studied, in generally calm or uncontrolled environments, the distribution factors of aquatic beetles: GUIGNOT (1959), BIGOT & MARAZANOF (1966), BERTHÉLEMY (1966). They highlight the following factors: nature of the water (salinity), depth, composition of the bottom and vegetation. In running water, other distributions factors may be added to those mentioned above that specify the environment at the station: altitude and maximum water temperature (MOUBAYED 1986, VINÇON & THOMAS 1987), current speed (HYNES 1970, MINSHALL 1984).

The importance of the nature of the substrate and the velocity must no longer be dismantled as a major factor in the distribution of aquatic invertebrates. They act in lotic environment by promoting the proliferation of rheophilic species belonging essentially, in the beetles, to the families of Hydraenidae, Elmidae and Hydrobiidae (in particular to the elements of the genus *Laccobius*), and at the same time reducing the lenitophilic species. In medium with little or no current and fine granulometry (sand, silt and mud) we see the opposite phenomenon: development of limnophilic species such as Haliplidae, Dytiscidae and regression of rheophilic species, which results in the maintenance of a relatively high specific richness in both types of environments.

The analysis of the longitudinal distribution of the beetles of the rivers studied, first results in the presence, in its entirety, of a stand with a limnophilic character and whose abundance from upstream to downstream seems to be governed by trophic resources and diversity of habitats. The highest species richness is found in medium and low altitude environments (140-500 m). The optimal proliferation of elements of this group in these areas can certainly be explained by the increase in the number of ecological niches due to the increase in the size of the rivers. The stations in these areas provide favourable environments for the establishment of a rich and diverse fauna thanks to relatively abundant surrounding and aquatic vegetation, a heterogeneous substratum rich in decomposing organic matter and a relatively high water temperature.

In spring streams and the plain, the number of collected species is considerably reduced. Elevation sites do not appear to be preferred locations for elements of this group of insects. Their poverty in beetles is probably the result of little or no aquatic vegetation, a stony substrate, relatively low water temperature and less trophic contributions than elsewhere. Similarly, the depletion of lowland stations is linked to the reduction of low water flow, the increase in water temperature during the summer and the negative impacts of different anthropogenic actions. In this type of environment, only large ecological valency species can persist.

The analysis of the population of the various environments surveyed allows us to recognize within the main families:

- species strictly localized in medium-high sites, with shady trails, rapid to medium water flow and relatively cool waters (8-16°C), which would characterize this area: *Hydraena mouzaïensis*, *H. pici*, *Elmis maugetii velutina*, *Hydroporus tessellatus tessellatus*, *Ochthebius* sp.1, *Helophorus asturiensis*;

- species related to potamal habitats, well known from this area in the Mediterranean basin: *Ochthebius semisemisericeus*, *Laccobius atrocephalus*, *L. femoralis mulsanti*, *Limnebius evanescens, Esolus pygmaeus*;

- species with wide distribution, eurytope and eurytherm: *Bidessus minutissimus.*

From a biogeographical point of view, the beetles recorded in this work are mostly Palearctic.

- Ten elements are from Asian origin and four from Afro-tropical one.

- 25 species have a wide geographical distribution, extending from North Africa to Middle and Western Europe to Asia;

- 12 are considered circum-Mediterranean;

- 18 with western Mediterranean distribution;

- 11 endemic to North Africa.

5. Conclusion

With 83 species or taxa, this study of some Kabylian rivers coming from Djurdjura mountains increased the inventory of Algerian beetles by seven species. This population includes a majority of Palearctic species widely distributed in the Mediterranean sub-region. Endemic species are primarily recruited from Elmidae (six species) and Hydraenidae (four species); only *Laccobius neapolitanus* is localized in North Africa. The longitudinal distribution of the elements of this group seems to depend here on environmental conditions: climate and hydrology on the one hand, trophic resources and anthropogenic influence on the other. The current (fast to medium) and the nature of the substrate (coarse granulometry) act by promoting the proliferation of rheophilic species belonging mainly to Hydraenidae, Elmidae and Hydrophilidae (genus *Laccobius*). In the lentic medium (low or no current, fine grain), the development of the lenitophilic species is rather observed in Hydrophilidae and Dytiscidae.

The faunistic analysis made it possible to highlight a great specific richness in the most heterogeneous regions of piedmont and low altitude. On the contrary, the reduction in the number of species upstream is due to constant environmental conditions. Similarly, in the plain, impoverishment is to be considered in relation to the negative impact of anthropogenic actions, low flow and excessive temperature increases.

Important taxonomic works are awaited to be carried out on coleoptera larvae and adults in the North African region. The exploration of new biotopes will certainly enrich this wildlife inventory and will allow better understanding of the distribution and ecology of species and especially those rare and localized.

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1. Distribution of Coleoptera in the study stations. 5 abundance classes: + (1–3 individuals), 2+ (4–10 ind.), 3 + (11–30 ind.), 4+ (31–100 ind.), 5+ (>100 ind.). (*) New citations for Algeria.

Tableau 1**.** Répartition des Coléoptères dans les stations étudiées. 5 classes d'abondance: + (1–3 individus), 2+ (4–10 ind.), 3 + (11–30 ind.), 4+ (31–100 ind.), 5 + (>100 ind.). (*) Citations nouvelles pour l'Algérie.

Species **Stations**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**S1**	**S2**	**S3**	**S4**	**S5**
Gyrinidae												
Gyrinus sp.							+					
Haliplidae												
Peltodytes (*Peltodytes*) *caesus caesus* (Duftschmid, 1805)					+							
Peltodytes (*P.*) *rotundatus* (Aubé, 1836)							+	4+	+	+		2+
Haliplus (*Neohaliplus*) *lineatocollis* (Marsham, 1802)				+	4+		+					
Haliplus sp.				+								
Dytiscidae Laccophilinae												
Laccophilus minutus (Linné, 1758)								+				
Laccophilus hyalinus (De Geer, 1774)				+	+			+				
Hydroporinae												
Bidessus coxalis Sharp, 1882				+	2+							
Bidessus minutissimus minutissimus (Germar, 1824)			+	+	4+	2+	3+	5+	4+	2+	+	2+
Deronectes fairmairei **(**Leprieur, 1876)					+		+					
Hydroporus obsoletus Aubé, 1838	+		+						2+			
Hydroporus planus (Fabricius, 1782)									+			
Hydroporus pubescens pubescens (Gyllenhal, 1808)	+	+	+	+	+	+	+					
Hydroporus tessellatus tessellatus (Drapiez, 1819)	+	+	+									
**Hydroporus tristis* (Paykull, 1798)	+	+	+	+	+	+	+					
Hydroporus sp.			+		+							
Hydrovatus sp.					+							
Hygrotus (*Hygrotus*) *inaequalis* (Fabricius, 1777)					+							
Graptodytes fractus fractus (Sharp, 1882)					+							
Graptodytes varius (Aubé, 1838)			+									
Nebrioporus clarkii (Wollaston, 1862)				2+	2+		+	5+	4+			
Rhithrodytes sexguttatus Aubé, 1838	+		+									
Scarodytes halensis halensis (Fabricius, 1787)				+								
Stictonectes escheri (Aubé, 1838)	+											
Yola bicarinata (Latreille, 1804)				+	2+				+			
Hydraenidae Hydraeninae												
Hydraena cordata Schaufuss, 1883		+										
Hydraena mouzaiensis (Sainte-Claire Deville, 1909)	3+	4+	4+									
Hydraena numidica Sainte-Claire Deville, 1905	+	4+	4+	+	+	+		+	+	+		
Hydraena pici Sainte-Claire Deville, 1905	+	2+	+									
Hydraena rivularis Guillebeau, 1896		+	+	+	+	+		2+	2+		+	
Limnebiinae												
Limnebius evanescens Kiesenwetter, 1866								+	+	+	+	
Limnebius sp.1	+		4+		+	+	+					
Limnebius sp.2						+	+					
Ochthebiinae												
Ochthebius (*Asiobates*) *dilatatus* Stephens, 1829									+			+
Ochthebius (*Ochthebius*) *difficilis* Mulsant, 1844			+		+		+					
Ochthebius (*O.*) *lobicollis* Rey, 1885					+							
**Ochthebius.* (*O.*) *pedicularius pedicularius* Kuwert, 1887	+	+						+	4+			
Ochthebius (*O.*) *semisericeus* Sainte-Claire Deville, 1914								3+	3+	+	+	
Ochthebius (*O.*) sp.1	+	3+	+									
Ochthebius (*O.*) sp.2		2+		2+		+	+					
Hydrochidae												
Hydrochus grandicollis Kiesenwetter, 1870									+			
Helophoridae												
Helophorus (Rhopalohelophorus) asturiensis Kuwert, 1885		2+										

Species **Stations**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**S1**	**S2**	**S3**	**S4**	**S5**
Helophorus (*Rhopalohelophorus*) *minutus* Fabricius, 1775	+		4+		+							
Hydrophilidae Hydrophilinae Berosini												
Berosus (Berosus) affinis Brullé, 1835								+		+		
Hydrophilinae Chaetarthriini												
**Chaetarthria seminulum* (Herbst, 1797)		+	+		+		+					
Hemisphaera seriatopunctata (Perris, 1874)		+	+									
Hydrophilinae Anacaenini												
Paracymus aeneus (Germar, 1824)	+	+	+		+							
Paracymus scutellaris (Rosenhauer, 1856)	+	+	+		+							
Paracymus sp.					+							
Anacaena bipustulata (Marsham, 1802)	+	+	+		+		2+					
Anacaena globulus (Paykull, 1798)	+	+	2+		+		+					
Hydrophilinae Laccobiini												
Laccobius (*Dimorpholaccobius*) *atrocephalus* Reitter, 1872								2+	4+		+	
Laccobius (*D.*) *hispanicus* Gentili, 1974									2+			
Laccobius (*D.*) *neapolitanus* Rottenberg, 1874				+		+	+					
Laccobius (*D.*) *sinuatus sinuatus* Motschulsky, 1849					2+	+						
Laccobius (*Hydroxenus*) *femoralis mulsanti* Zaitzev, 1908								5+	5+	5+		+
Laccobius (*Microlaccobius*) *praecipuus* Kuwert, 1890			+	+			+					
Laccobius sp.					+			2+				
Hydrophilinae Hydrophilini												
**Cymbiodyta marginella* (Fabricius, 1792)							+					
Sphaeridiinae												
**Coelostoma* (*Coelostoma*) *hispanicum* (Küster, 1848)											+	
Hydroscaphidae												
**Hydroscapha granulum* (Motschulsky, 1855)									2+		+	
Hydroscapha sp.			+		+	+	+					
Helodidae												
Helodes sp.1			2+		+	+	2+					
Helodes sp.2			2+		+							
Hydrocyphon sp.	+	2+	2+	+	+		+					
Prionocyphon sp.					+							
Dryopidae												
Dryops algiricus (Lucas, 1846)					2+		2+					
Dryops gracilis (Karsch, 1881)		+	+									
Dryops lutulentus (Erichson, 1847)					2+	2+	3+					
**Dryops nitidulus* (Heer, 1841)					2+	+	3+					
Dryops subincanus (Kuwert, 1890)								+	+	+		
Elmidae												
Elmis maugetii velutina (Reiche, 1879)	2+		2+									
Esolus filum (Fairmaire, 1870)	+		4+	4+	4+	4+	3+					
Esolus pygmaeus (P.W.J. Müller, 1806)								3+	4+		+	+
Esolus sp.								3+	5+		+	+
Limnius opacus opacus P.W.J. Müller, 1806	+		4+	4+	4+	4+	4+	4+	4+		+	2+
Limnius surcoufi (Pic, 1905)						+	+					
Normandia villosocostata (Reiche, 1879)				+	+	+	+					
Oulimnius maurus Berthélemy, 1979	+		+	2+	4+	+	3+		+			+
Oulimnius villosus Berthélemy, 1979				+	+	+						
Oulimnius sp.								+	+	+	+	+
Stenelmis consobrina consobrina Dufour, 1835						+	2+	+	+			