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Contribution to the knowledge of the population of riparianbeetles in the region of Guelmim – Oued Noun (Moroccan Sahara)

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Abstract :
The presentwork provides an exhaustive inventory (as possible) and contributes to the study of the biodiversity of the population of riparianbeetles in four zones of the region of Guelmim – Oued Noun: Assa-zag, Guelmim, TanTan and Sidi Ifni, in each area, using , pitfall traps, beating and sighthuntingwere able to identify 316 individuals; 84 speciesidentified, belonging to 11 Families (Cicindelidae, Carabidae, Cetoniidae, Staphylinidae, Dynastidae, Malachiidae, Scarabaeoidea, Buprestidae, Coccinellidae, Tenebrionidae, Anthicidae). The familyTenebrionidaedemonstrated a consistent trend within the majority of the beetle population. The mostwidespreadfamily and the best adapted to climatic conditions. Throughhierarchical classification, it was revealed that there werefaunalsimilaritiesbetween the different sites, leading to the identification of five main groups. Additionally, itwasnotedthat the prevailingclimatic conditions in the study area played an important role in the formation of beetle assemblages, affectingboththeirabundance and speciesdiversity. A comprehensive understanding of these factorsis crucial for the development of effective conservation strategiesaimed at ensuring the survival of thesebeetles. However, furtherresearchisneeded to explore other potential factors that may influence beetlebiodiversity.
Keywords : Riparianbeetles, Diversity, Distribution ,Guelmim-Oued Noun region ,Southern Morocco.

Introduction

Riparianbeetles are an integral component of streamsideecosystems, playing a crucial role in maintainingecological balance, thesebeetlescontributesignificantly to nutrientcycling and soilaeration, and serve as vital indicators of environmentalhealth(Zumstein et al., 2021).
A survey of the distribution and ecology of riparianbeetles in Fennoscandia and adjacent countries revealedtheir conservation value and the threatsthey face. The biodiversity of riparianbeetles in the Sidi Moussa-Oualidiawetland of Atlantic Morocco wasalsostudied, highlightingtheir importance in the ecosystem(Iradati et al., 2017). Understanding the diversity and distribution of riparianbeetlesis essential for ecologicalstudies and conservation efforts. Their

unique habitat requirements and vulnerabilitymakethem sensitive to environmental changes, makingthemvaluableindicators of ecosystemhealth.

The Guelmim – Oued Noun region, located in the Moroccan Sahara, presents a unique and understudied habitat for riparianbeetles. Characterized by its distinct climatic conditions and diverse ecological zones, thisregionprovides an ideal setting for studyingbeetlebiodiversity. The specific zones of Assa-zag, Guelmim, TanTan, and Sidi Ifni, eachwiththeirownenvironmentalcharacteristics, offer a richtapestry for ecological exploration.The Guelmim-Oued Noun regionspans an area of 46,108 km² (6.49% of the national territory), bordered by the Sousse Massa region to the north, the Laayoune-Sakia Al Hamra region to the south, Algeria and the Islamic Republic of Mauritania to the east, and the Atlantic Ocean to the west. It isdividedinto 4 provinces (Guelmim; Assa-Zag; Sidi Ifni; TanTan).

The overallclimateischaracterized by hot summers and mildwinters, withannualprecipitationrangingfrom 50 to 200 mm, and temperaturesreaching up to 50°C in summer (MONOGRAPHIE DE LA REGION GUELMIM-OUED NOUN 2019, n.d.).

The study of entomologicalfauna in the Moroccan Sahara has been sporadic and incomplete, withonlyscattered investigations conducted over the years. Seriousstudiesbegan in the early 2000s, with notable contributions fromGomy et al. (2011), Piñero et al. (2009), Cuzin (2003), and Nabozhenko (2015). Despitethese efforts, the entomofauna of thisregionremainspoorlyunderstood and inadequatelyexplored.

This lack of comprehensiveentomological data has prompted us to undertake a detailedstudy of riparianinsects in the Guelmim – Oued Noun region. Our goal is to address the deficit in knowledge and contribute to the understanding of the region'sentomologicalbiodiversity. To compile an inventory of riparianfauna, sampleswerecollectedacross the entire area, tailored to the characteristics of eachsurveyed station. Our studyaims to assess the diversity, heritage value, and uniqueness of beetle populations in the Saharan biotopes of the Guelmim – Oued Noun region.

Despite the recognized importance of biodiversitystudies, thereis a notable gap in comprehensiveresearchfocused on riparianbeetleswithinthis area. Existingstudies have largelyoverlookedthisregion, leaving a significantvoid in ourunderstanding of these vital insects and theirecologicalroles.

This studyaims to fillthis gap by providing an exhaustive inventory of riparianbeetles in the Guelmim – Oued Noun region. Throughmeticulous collection and identification methods, includingpitfall traps, beating, and sighthunting, weaim to catalog the speciespresent, analyzetheir distribution and abundance, and understand the influence of climatic conditions on their populations. Additionally, hierarchical classification willbeused to identifyfaunalsimilaritiesacrossdifferent sites, furtherenrichingourunderstanding of thesebeetle assemblages.

The findings of thisstudy are crucial for developing effective conservation strategies. By gaining a comprehensiveunderstanding of the factorsinfluencingbeetlebiodiversity, we can betterensure the survival of thesespecies. Moreover, thisresearchlays the groundwork for future studies to explore additionalfactorsaffectingbeetle populations, ultimatelycontributing to the broaderfield of biodiversity conservation.

In conclusion, thisstudy not onlyaddresses a significant gap in ourknowledge of riparianbeetles in the Moroccan Sahara but also highlights the importance of continuedresearch and conservation efforts in this unique region.

1. Materials and Methods

The studywasprimarilyconductedbetween March 25, 2019, and January 24, 2020, during the period of adultactivity.

2.1. Description of the Study Area

Renowned for its distinct climate, precipitation patterns, and soilquality, the Guelmim Oued Noun region (see Fig. 1) boasts a remarkablevariety of soil types, encompassingsandy, clayey, and loamy compositions. Eachsoil type possessesitsownattributes and fertilitylevels, profoundlyinfluencing plant growth and agriculture throughout the region. Thesefactorscollectivelypromoteflourishingvegetation and abundant agricultural opportunities in the area.

2 .2. Selection of Stations

The selection of stations wasbased on variousfactors, including altitude, biodiversity of habitats, and accessibility to study sites. The following stations wereidentified as primary (Table I):

- Assa-zag, town (S1) (28° 36′ 31″ N; 9° 25′ 37″ W). Located 100 km southeast of Guelmim, at an altitude of 260-500m;classifiedwithin the Saharan warm winter group (Fig. 2), this station ischaracterized by the presence of numerousoases.
- Guelmim, town (S2) (28°59′13″ N; 10°03′26″ W). Situated 200 kilometerssouth of Agadir, 110 kilometersfrom Tiznit, and 30 kilometersfrom the Atlantic Ocean, at an altitude of 301m;this station fallswithin the Saharan warm winterbioclimatic zone (Fig. 2); itisconsidered the gateway to the Moroccan Sahara, connecting the desert to the sea.
- Sidi Ifni, town (S3) (29°22′47″N; 10°10′22″ W), at an altitude of 44m. Located on the southerncoast of Morocco, between Tiznit and Guelmim, 160 km south of Agadir. Situated in the Anti-Atlas mountain range, Sidi Ifni isperched on the southernslope, along the ocean'sedge;this station fallswithin the Arid warm winterbioclimatic zone (Fig. 2).
- Tan-Tan, town (S4) (28°26′16″ N; 11°06′11″ W). Located 330 km south of Agadir in southwestern Morocco, at an altitude of 45m. Flanked by twowadis - the Draa and Chebikawadis - whicheventually flow into the ocean. The wadis are bordered by sanddunes;this station isclassifiedwithin the Saharan warm winterbioclimatic zone (Fig. 2).

The climaticattributes of the stations are presented in Table 1, while Figure 2 illustrates the compilation of theseattributes. By carefullyselecting stations in the Guelmim Oued Noun region, itbecomes possible to examine the evolution of the faunal composition of beetle populations over a period of twoyears.

2. 3. Trapping

To collectbeetlefauna, weemployedseveraltrappingmethods:

- **Visual hunting**: This methodinvolvescollecting all speciesencounteredvisually, under stones and debris. This prospectingcovers a large area of land.
- **Beating**: Branches of trees are beaten over a collectingsheet at the height of a person. Insectsfalling onto the sheet are thenaspiratedusing an entomological vacuum. This methodisutilized for insects living on the foliage of trees, known as frondicole species.
- **Baittraps**: This methodinvolves the use of a simple pot, 8 cm deep and 16 cm in diameter. The pot isburiedverticallysothat the openingisslightly flush with the ground. It isfilled to one-third of itsheightwithfish (sardines) as bait.
- **Sand sifting**: This methodinvolvessiftingsand over a large area and collecting all speciesobserved in the sieve.

2. 4. NumericalAnalysis

The fundamental objective of diversity indices is to summarize the number of species and theirproportionalabundances (Hill, 1973). To achievethis, weutilizetwo types of indices to analyzefaunaldata:

- Shannon Diversity Index (H') :

$H'=-\sum i=1S(Nni)\ln(Nni)$

The Shannon Diversity Index (H') measures the diversity in a community. It accounts for both the abundance and evenness of the speciespresent. The higher the value of H', the greater the diversity.

- The equitability index (E) :

$E=H'\ln(S)E=\ln(S)H'$

The Equitability Index (E), alsoknown as Pielou'sEvenness Index, assesses how evenly the individuals are distributedamong the differentspecies. It rangesfrom 0 to 1, where a value closer to 1 indicates a more even distribution of individualsamongspecies.

where:

ni:represents the number of individuals of a givenspecies*i*.

N:denotes the total number of individualscounted, encompassing all species.

S:indicates the total number of species.

3. Results

3 .1. Community Analysis

The compilation of beetlespeciesinventoried in the four stations ispresented in Table II. In total, 84 specieswererecorded, consisting of 316 individualsbelonging to 11 families, eachwithvarying proportions (Table II). The familyTenebrionidaedominateswith 46 species, representing 54.76% of the total. Following closely are the familyCarabidaewith 16 species (19.04%), and the familyStaphylinidaewith 5 species (5.95%). The familyScarabaeidae, as well as the familiesCetoniidae and Anthicidae, eachcontribute 4 and 3 species, respectively. The remainingfamiliesaccount for 1 to 2 species, representing 1.19% and 2.38% respectively (Figure 3).

3.2. Faunal Composition

The entire set of 316 collectedindividuals has been classified by family. Tenebrionidaeis the mostrepresented (54% of individuals and 55% of collected taxa) (as shown in Figures 3 and 4). The familyCarabidaecloselyfollows in terms of taxonomicrichness, representing 25% of taxa, while the familyCetoniidae in terms of abundance (7%). Within the familyTenebrionidae, there are 5 subfamilies, with the subfamilyPimeliinaebeing the mostsignificant, encompassingapproximately 68% of the taxa of the total population. In second position are the Blaptinae, representing 27% of the taxa. The subfamiliesAlleculinae and Diaperinaeeachcontribute 2% in terms of abundance, while the subfamilyTenebrioninaeholds a taxonomicrichness of 2% (Fig. 4).

The resultsobtained are consistent with the observations made by (Piñero et al., 2009), whoalso note the prevalence of Tenebrionidae in the riparianfauna of southern Morocco, as in mostriparianenvironments.

3.3. Biogeographical Composition

By analyzing the data provided in Figure 5, itbecomesevidentthat the speciesexamined in the study can beclassifiedinto four main groups:Mediterranean (constituting 50% of the total), Palearctic (22%), North African (19%), and finally, the Endemic group (9%). A significant portion of the population, approximately 50%, iscomposed of

Mediterraneanspeciesdistributedthroughout the Mediterranean basin, including Scarites buparius, Scarabaeuslaticollis, Euoniticelluspallens, and Exochomusnigripennis. Palearcticspecies, distributedacross Europe, North America, and northern Asia, representapproximately 33.3% of all species, such as Cymbionotumsemelederi, Bembidionvarium, and Bembidionatlanticum. Among the recordedspecies, accounting for 19% of the total, are thosefound in North Africa, particularly in Algeria, Morocco, and Tunisia. TheseincludeChlaeniuscanariensis, Cymindisdiscophora, Cymindissuturalis, Blaps nitens, and Blaps tingitana.

In terms of Moroccanendemicspecies, theyrankfourth, representing 22% of all knownspecies. TheseincludePimeliacordata, Blaps inflata, and Pimeliacordata (Saouache et al., 2021) (Bedel&Bedel, 1895) (Pupier, 2005).

3.4. Spatial TaxonomicRichness

The resultsreveal spatial variation in speciesrichness, relative abundance of species, and familyrichnesspresent in different areas. Thus, weidentified 84 taxa of beetlesbelonging to 11 families, with an uneven distribution among the differentstudyregions. The Assa-Zag and Guelmim stations exhibit a greatervariety of families and specificrichness, as well as a notable relative abundancecompared to thatnoted in TanTan and Sidi Ifni (Figure 6).

3.3 Exclusive Species

The relative abundance of beetles in different areas (Table II) varies depending on specificspecies and the areas studied. At the Assa-zag station, Bembidionatlanticumrepresents 9.52%, while at the Guelmim station, Erodiuszophosoides and Mecynotarsus bison represent 18.89% of the population. At the Tantan station, Pimeliacordata, Eulipuselongatus, and Falsocaediusfossulatuscontribute 17.24%, and at the Sidi Ifni station, Thalpobiarolphirepresents 23.52%.

In terms of diversity, the Assa-Zag and Guelmim stations stand out as the mostvaried, with respective values (H = 3.637 bits; E = 0.8957) and (H = 3.051 bits; E = 0.9155) (Figure 6). The Tantan Station ismoderatelydiversified (H = 2.212 bits; E = 0.9155). On the other hand, the Sidi Ifni Station exhibitslowerdiversitycompared to the previousones, with a value of H = 2.212 bits, but compensateswith a high value of E (Evenness) of 0.9555 (Figure 7).

3.4 Analysis of Results

The variability of the data isexplained by 45.8% and 22.4% by the axes of the CorrespondenceAnalysis. Axis 1 clearlydistinguishes the Guelmim and TanTan stations, closelyassociatedwithTenebrionidae, Carabidae, Anthicidae, Cetoniidae, and Buprestidae. Conversely, the stations are mainlycorrelatedwith the presence of Tenebrionidae (Fig. 8). Axis 2 differentiates the Sidi Ifni station, mainly due to the presence of most of the Tenebrionidaespeciesfound in this station (Fig. 8).

Within group I, thereis a total of 20 species, the majoritybelonging to the familyTenebrionidae, representing 12 species and accounting for two-thirds of all recordedspecies. Additionally, the familyAnthicidaeisalsowellrepresented, accounting for 40% of the recordedspecies. This group islocated in the positive part of axis F2 of the CA (Fig. 8).

Group II (58 species, Fig. 9) comprises a balancedrepresentation of Carabidae, Cetoniidae, Dynastidae, and Malachiidae, totaling 58 species. However, the familyTenebrionidaeoverwhelminglydominatesthis group, representing 84.50% of the recordedspecies. The entire group islocatedentirely in the negative part of axis F1 of the CA (Fig. 8).

Group III, whichincludes 65 species (Fig. 9), has Tenebrionidae, Carabidae, Staphylinidae, Scarabidae, Cicindelidae, and Cetoniidaerepresenting 42%, 22%, 9%, 6%, and 5% of all species, respectively, withintheir respective families. This group islocated in the negative part of axis F1 of the CA (Fig. 8).

Group IV (149 species, Fig. 9) islargelydominated by Tenebrionidae (67 species), whichrepresentnearlyhalf of the total number of recordedspecies. Carabidae (60 species) and Cetoniidae (17 species) are wellrepresented in this group (representing 40% and 11% of the total number of recordedspecies, respectively). This group isentirelylocated in the negative part of axis F1 of the CA (Fig. 8).

Group V (18 species, Fig. 9) contains a majority of insects, with the mostrepresentedspeciesbeingTenebrionidae (16 out of the total number of recordedspecies). This group isentirelylocated in the positive part of axis F1 of the CA (Fig. 8).

Discussion

thepreliminaryinventory of riparianbeetle populations in the regionyielded a comprehensive compilation of 82 distinct species. These observations demonstrate the significantfaunaldiversitypresent in the area, reflectingitsremarkableecological importance and biologicalrichness in thisarid zone. The beetlescollectedexhibit a transition betweenMediterranean and Saharan populations, withsome taxa found at the limits of their distribution (Daoudi et al., 2017).

However, the searchresultsindicatethat the riparianbeetlefauna in otherregions of Morocco has been more extensivelystudied. For example, a survey of the Sidi Moussa-Oualidiawetland in Atlantic Morocco revealed the biodiversity and ecology of riparianbeetles in thisprotected Ramsar site. The distribution of aquaticbeetles in the easternregion and the Moulouya watershed has also been documented(Iradati et al., 2017; Mabrouki et al., 2018.)while the research highlights the need for more comprehensivesurveys of riparianbeetles in the Moroccan Sahara, particularly in the Guelmim – Oued Noun region, other areas of Morocco have received more attention in terms of studying the diversity and distribution of thesebeetles.

The Guelmim – Oued Noun region in the Moroccan Sahara presents a unique and understudied habitat for riparianbeetles. Characterized by a transition from a moderatelycontrastedMediterraneanclimate to a hot, arid semi-continental climate, thisregion supports a diverse array of terrestrialspecies. Our comprehensiveinventorying efforts have yieldedvaluable insights into the ecologicaldiversity of the area, identifying a total of 84 beetlespeciesdistributedamong 11 differentfamilies.

The preliminaryinventory of riparianbeetle populations in the Guelmim – Oued Noun regionrevealed a significantfaunaldiversity, with 84 distinct speciesreflecting the remarkableecological importance and biologicalrichness of thisarid zone. The beetlescollecteddemonstrate a transition betweenMediterranean and Saharan populations. SomeMediterranean taxa are found at the southernlimit of their distribution, such as *Lophyra (Lophyra) flexuosaflexuosa, Dyschirius (Dyschiriodes) punctatus, Bembidion (Notaphus) varium, Euoniticelluspallens, and Scarabaeus (Ateuchetus) laticollis*. Conversely, otherSaharan taxa reachtheirnorthernlimit, including*Scarites (Scallophorites) buparius, Tropinota (Tropinota) squalidapilosa, and Adesmia (Oteroscelopsis) dilatatagetula*. These observations underscore the influence of beetle populations on the entomological composition of the region.

To assessbeetlediversity and abundance, the researchersutilized the Shannon diversity index (H') and Evenness (E). The studyhighlighted the importance of the Saharanbioclimatic zone, classified as a Saharanecosystemwith a warm winter. Resultsindicated a positive correlationbetweenbeetlediversity and factorssuch as vegetation cover. However, the potential impact of humanactivities, such as land use changes and climate change, on beetle populations was not considered.

The studyalso highlights the overlappingvegetationalgeographicalboundariesinfluenced by semi-arid conditions in the south and moderatecontrastingheatnear the coast, affected by humidmonsoonal air, frequentseafog, and winds (Guerre, 1939-1945). This climatic transition contributes to the abundance of terrestrialspecies in the region.
Beetles are excellent bioindicators due to theirsensitivity to environmentalfactors and their efficient dispersal abilities. Theirremarkablewalkingability and adaptability to fragmentedlandscapesfurtherenhancetheir aptitude for thisrole(Chowdhury et al., 2023; Rainio and Niemelä, 2003).*. Factorssuch as climate, litterquality and quantity, and habitat stabilitysignificantly impact beetle populations by affecting the availability of food sources (Zouaki, 2019). Ground beetles (Coleoptera:Carabidae), in particular, are frequentlyused as bioindicators of habitat alteration. Typically, large, poorlydispersingspecialistspeciesdecreasewithincreaseddisturbance, whilesmallgeneralistspecieswith good dispersal abilityincrease. Somespeciesremainunaffected by moderatedisturbance. Beetles, particularlythose in the Carabidae, Staphylinidae, and Scarabaeidaefamilies, can detectenvironmental changes and assess the impact of alterations.
The studyunderscores the importance of implementingadequate, ecological, and sustainable management measures to preserve the biodiversity of thisarid zone. The conservation of thisregionis crucial, as itprovidesongoingopportunities for discovering new species in Moroccanfauna. By contributing to the establishment of appropriate conservation measures, thisresearchaims to protect the richbiodiversity of the Guelmim – Oued Noun region.
In conclusion, the preservation of the richbiodiversity in the Guelmim – Oued Noun regionis crucial and depends on implementing effective management measures. This study highlights the importance of conservingthisarid zone and emphasizesitspotential for furtherdiscoveries in Moroccanfauna. The ongoing observation and discovery of new speciesunderscore the ecologicalsignificance of the region and the need for continued conservation efforts.

Author Contributions

H'MAIDA

- Data curation, handling and organizing research data.
- Active involvement in the investigation process.
- Methodological contributions to the study.
- Validation of research findings.
- Writing the original draft of the manuscript.
- Participating in the review and editing of the manuscript.

HNINI

- Validation of research findings.
- Writing the original draft of the manuscript.
- Participating in the review and editing of the manuscript.

Fekhaoui

- Conceptualization of the research.
- Funding acquisition for the project.
- Investigation as part of the research process.
- Methodological contributions to the study.
- Project administration responsibilities.
- Access to necessary resources for the research.
- Overall supervision of the project.

Institutional Review Board Statement

Not applicable.

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Data Availability Statement

Not applicable.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflicts of Interest

All authorsdeclare that they have no conflicts of interest regarding the publication of this paper.

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Tables and Figures

Table I. Geographic and climaticcharacteristics of the studied stations

Bioclimatic Zone	Stations	Localities	Coordinates	Altitude (m)
Saharan Warm Winter	Assa-Zag			
	Pt 1	Station de l'I.S. à AouinetTorkoz (= AouinetLahna)	28°28'21" N - 09°51'20" W	290
	Pt 2	Between Assa and Zag;bed of the Draa wadi	28°29'27" N - 09°24'10" W	207
	Pt 3	Zag;bed of the wadi	28°01'04" N - 09°17'48" W	398

	Pt 4	South of Zag; Acacia forest	28°00'12" N - 09°17'36" W	409
	Pt 5	Zag	28°01'11" N - 09°50'58" W	412
	Pt 6	Northwest of AouinetLahna on the P1308	28°31'51" N - 09°59'27" W	500
	Pt 7	Southeast of AouinetLahna; Ouin Mesdour	28°26'27" N - 09°45'55" W	260
	Pt 8	Southwest of Assa on P1308	28°31'20" N - 09°33'05" W	283
	Pt 9	Aïn Isker	28°32'23" N - 10°01'17" W	502
	Pt 10	South of the I.S. station at AouinetLahna (track)	28°26'32" N	
	Pt 11	Tiglitsurroundings;wadibed	28°28'31" N - 10°18'52" W	280
	Pt 12	BetweenIcht and Taghjijt	29°03'14" N - 09°19'56" W	630
Saharan Warm Winter	Guelmim			
	Pt 13	Taghjijt;water'sedge	29°03'51" N - 09°25'24" W	570
	Pt 14	Southwest of El Borj	28°38'40" N - 09°53'46" W	440
	Pt 15	FoumAssaka; Plage Blanche	28°57'49" N - 10°36'18" W	0-10
	Pt 16	FoumAssaka, Guelmim road	28°57'38" N - 10°34'23" W	45
Saharan Warm Winter	TanTan			
	Pt 17	El Ouatia;beach	28°30'20" N - 11°19'30" W	0-15
	Pt 18	Foum Draa wadi	28°40'35" N - 11°07'23" W	oct-30
	Pt 19	Ouin Madkour	28°23'20" N - 10°50'21" W	163
Arid Warm Winter	Sidi Ifni			
	Pt 20	Between Sidi Ifni and Mirleft;Legzirabeach	29°26'24" N - 10°07'10" W	42

Tableau II. Liste des espèces de Coléoptères échantillonnées dans les Quatre zones d'étude de la Région de Guelmim Oued Noun (2019-2020)

			Assa-Zag		**Guelmim**		**TanTan**		**Sidi Ifni**	
Family	Genus/Species	Abbreviations	S	AR %	S	AR %	S	AR %	S	AR %

Cicindelidae	*Lophyraflexuosa*	Ci-Lo fle	2	0.952	2	35.714	0	0	0	0
Carabidae	*Scarites buparius*	C-Sc bu	0	0	1	17.857	1	3.448	0	0
	Pheropsophus africanus	C-Ph afr	7	3.333	0	0	0	0	0	0
	Dyschiriuspunctatus	C-Dy pun	1	0.476	0	0	0	0	0	0
	Cymbionotumsemelederi	C-Cysem	1	0.476	0	0	0	0	0	0
	Bembidionschmidti	C-Be sch	1	0.476	0	0	0	0	0	0
	Bembidionvarium	C-Be var	1	0.476	0	0	0	0	0	0
	Bembidionatlanticum	C-Be atl	20	9.524	0	0	0	0	0	0
	Tachyuracurvimana	C-Tacur	2	0.952	0	0	0	0	0	0
	Perileptusareolatus	C-Pe are	1	0.476	0	0	0	0	0	0
	Abacetussalzmanni	C-Ab sal	1	0.476	0	0	0	0	0	0
	Paranchusalbipes	C-Pa alb	1	0.476	0	0	0	0	0	0
	Chlaeniusspoliatus	C-Chspo	8	3.81	0	0	1	3.448	0	0
	Chlaeniuscanariensis	C-Ch can	16	7.619	0	0	0	0	0	0
	Masoreus orientalis	C-Ma ori	2	0.952	0	0	0	0	0	0
	Cymindisdiscophora	C-Cy dis	3	1.429	0	0	0	0	0	0
	Cymindissuturalis	C-Cy sut	8	3.81	0	0	0	0	0	0
Cetoniidae	*Oxythyreafunesa*	Ce-Ox fun	15	7.143	2	35.714	0	0	0	0
	Paleirafemorata	Ce-Pa fem	0	0	2	35.714	0	0	0	0
	Tropinotasqualida	Ce-Tr squ	3	1.429	0	0	0	0	0	0
Staphylinidae	*Anaulacaspisformosa*	St-An for	3	1.429	0	0	0	0	0	0
	Philonthusconcinnus	St-Ph con	1	0.476	0	0	0	0	0	0
	Gabriusnigritulus	St-Ga nig	1	0.476	0	0	0	0	0	0
	Gauropterusfulgidus	St-Ga ful	1	0.476	0	0	0	0	0	0

	Tachyporusnitidulus	St-Ta nit	1	0.476	0	0	0	0	0	0
Dynastidae	*Podalguscuniculus*	D-Po cun	1	0.476	1	17.857	0	0	0	0
	Pentodonalgerinum	D-Pealg	1	0.476	0	0	0	0	0	0
Malachiidae	*Attalus cf.poweli*	M-Atpow	0	0	2	35.714	0	0	0	0
Scarabaeidae	*Scarabaeuslaticollis*	Sc-Sc lat	0	0	0	0	0	0	2	11.8
	Euoniticelluspallens	Sc-Eu pal	2	0.952	0	0	0	0	0	0
	Onthophagustranscaspicus	Sc-On tra	2	0.952	0	0	0	0	0	0
	Onthophagusnebulosus	Sc-On neb	2	0.952	0	0	0	0	0	0
Buprestidae	*Acmaeoderaquadrifasciata*	B-Ac qua	1	0.476	0	0	0	0	0	0
	Paratassacoraebiformis	B-Pa cor	0	0	1	17.857	0	0	0	0
Coccinellidae	*Exochomusnigripennis*	Co-Ex nig	5	2.381	0	0	0	0	0	0
Tenebrionidae	*Adelostomasulcatum*	T-Ad sul	1	0.476	0	0	0	0	0	0
	Machlopsisincostata	T-Mainc	0	0	1	17.857	0	0	0	0
	Adesmiabiskreensis	T-Ad bis	8	3.81	2	35.714	2	6.897	0	0
	Adesmiadilatata	T-Ad dil	2	0.952	2	35.714	0	0	0	0
	Adesmiametallica	T-Ad met	1	0.476	1	17.857	0	0	2	11.8
	Akislozanoi	T-Akloz	1	0.476	0	0	0	0	0	0
	Alphasidaconspuata	T-Al con	0	0	0	0	0	0	1	5.88
	Erodiusexternus	T-Erext	0	0	2	35.714	1	3.448	0	0
	Erodiuszophosoides	T-Erzop	0	0	8	14.286	0	0	0	0
	Pimeliaechidna	T-Pi ech	0	0	0	0	0	0	1	5.88
	Pimelia grandis	T-Pi gra	3	1.429	1	17.857	0	0	0	0
	Pimelia simplex	T-Pi sim	6	2.857	0	0	0	0	0	0
	Pimeliacordata	T-Pi cor	0	0	1	17.857	5	17.24	0	0

Pimeliasubquadrata	T-Pi sub	0	0	1	17.857	0	0	0	0
Thripteramaroccana	T-Th mar	1	0.476	0	0	0	0	0	0
Sepidiumhystryx	T-Sehys	0	0	0	0	0	0	2	11.8
Trachydermahispida	T-Tr his	2	0.952	0	0	0	0	0	0
Catomulusolcesii	T-Caolc	0	0	2	35.714	3	10.34	0	0
Eulipuselongatus,	T-Eu elo	0	0	1	17.857	5	17.24	0	0
Mesosenaangusata	T-Me ang	6	2.857	0	0	0	0	0	0
Oterophloeusalveatus	T-Otalv	6	2.857	0	0	0	0	0	0
Oxycaragasonis	T-Ox gas	9	4.286	0	0	0	0	0	0
Pachychilatransversithorax	T-Pa tra	0	0	0	0	0	0	3	17.6
Tentyrina senegalensis	T-Te sen	4	1.905	0	0	0	0	0	0
Tentyronotarotundicollis	T-Te rot	5	2.381	0	0	0	0	0	0
Thalpobiarolphi	T-Th rol	0	0	0	0	0	0	4	23.5
Trichosphaenaperraudieri	T-Tr per	0	0	1	17.857	0	0	0	0
Zophosisnigroaenea	T-Zonig	2	0.952	0	0	0	0	0	0
Zophosisbicarinata	T-Zobic	4	1.905	3	53.571	3	10.34	0	0
Blaps inflata	T-Blinf	0	0	1	17.857	0	0	0	0
Blaps nitens	T-Bl nit	1	0.476	0	0	2	6.897	2	11.8
Blaps tingitana	T-Bl tin	0	0	1	17.857	1	3.448	0	0
Cheirodes brevicollis	T-Chbre	0	0	1	17.857	0	0	0	0
Clitobiusoblongiusculus	T-Cl obl	6	2.857	0	0	0	0	0	0
Clitobiusovatus	T-Cl ova	0	0	1	17.857	0	0	0	0
Falsocaediusfossulatus	T-Fa fos	0	0	2	35.714	5	17.24	0	0
Gonocephalumperplexum	T-Go per	2	0.952	0	0	0	0	0	0

	Gonocephalumpatruele	T-Go pat	2	0.952	0	0	0	0	0	0
	Gonocephalumsericeum	T-Go ser	3	1.429	0	0	0	0	0	0
	Gonocephalumsetulosum	T-Go set	7	3.333	0	0	0	0	0	0
	Gonocephalumsoricinum	T-Go sor	2	0.952	0	0	0	0	0	0
	Opatroidespunctulatus	T-Oppun	6	2.857	0	0	0	0	0	0
	Sabulariusmimeuri	T-Samim	1	0.476	0	0	0	0	0	0
	Scaurusmicrocephalus	T-Sc mic	0	0	1	17.857	0	0	0	0
	Phtoraangusta	T-Ph ang	3	1.429	0	0	0	0	0	0
	Heliostrhaemapoweli	T-Hepow	0	0	4	71.429	0	0	0	0
Anthicidae	*Cordicollisopaculus*	A-Co opa	1	0.476	0	0	0	0	0	0
	Stricticomusophthalmicus	A-St oph	1	0.476	0	0	0	0	0	0
	Mecynotarsus bison	A-Me bis	0	0	8	14.286	0	0	0	0

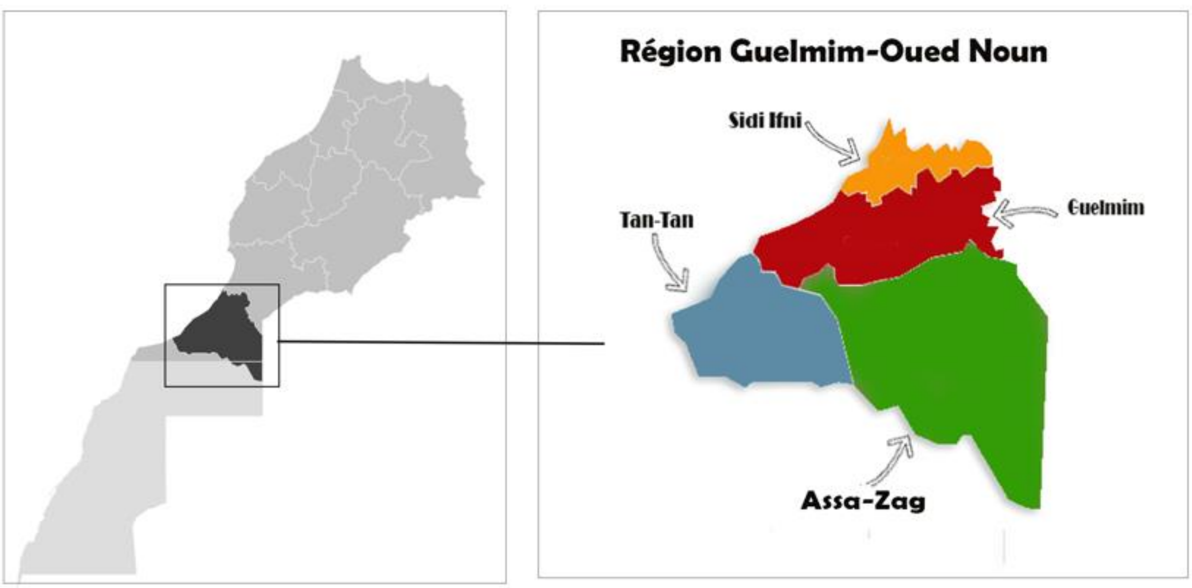

Figure 1 : Geographical Location of the Study Area

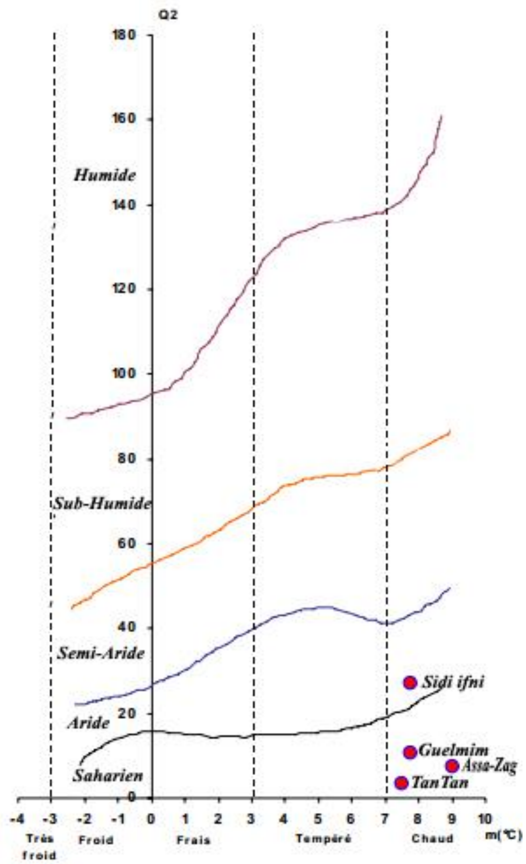

Figure 2:Position on a Climatic Diagram of the Four Provinces in DifferentBioclimatic Zones Based on Values

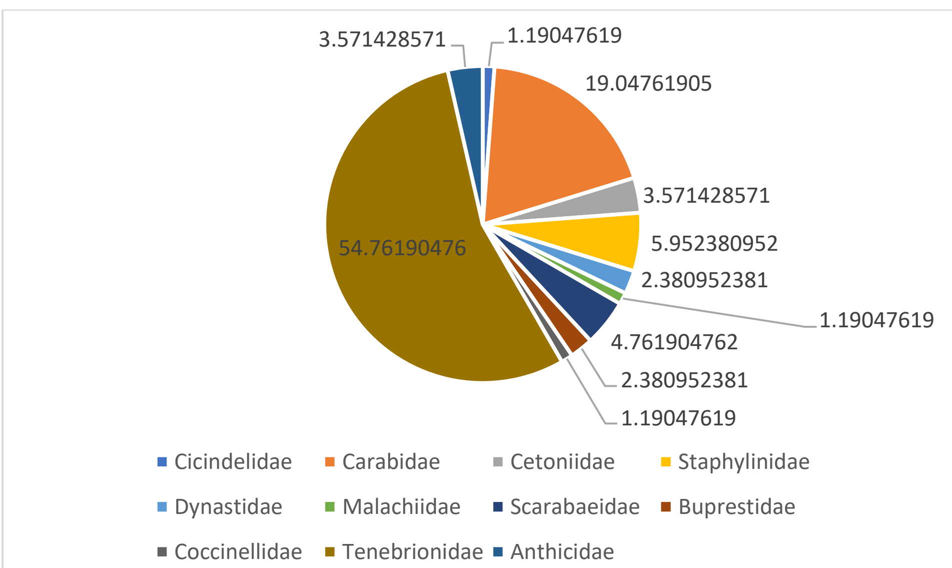

Figure 3 : Family richness over the studyperiod

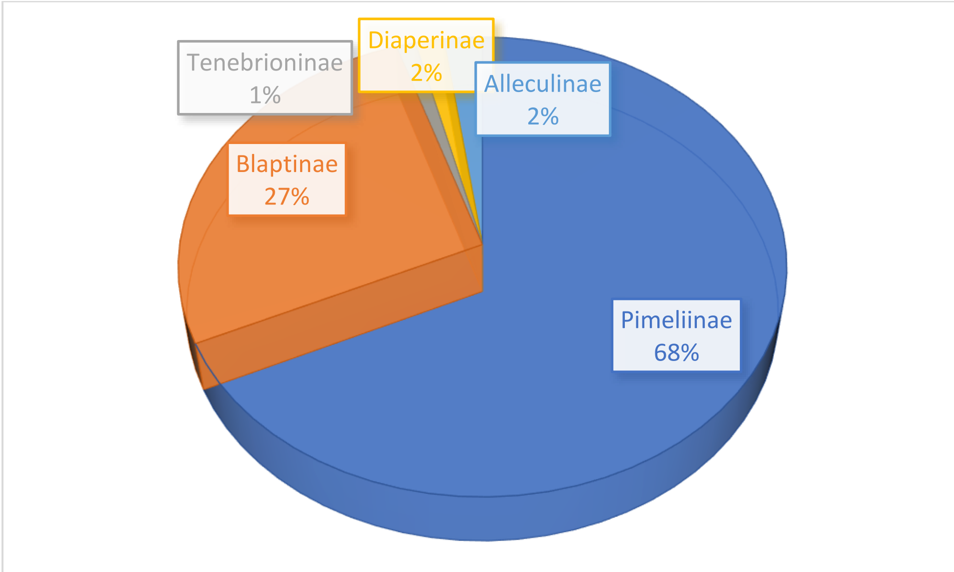

Figure 4:Biogeographical distribution of global taxa in populations

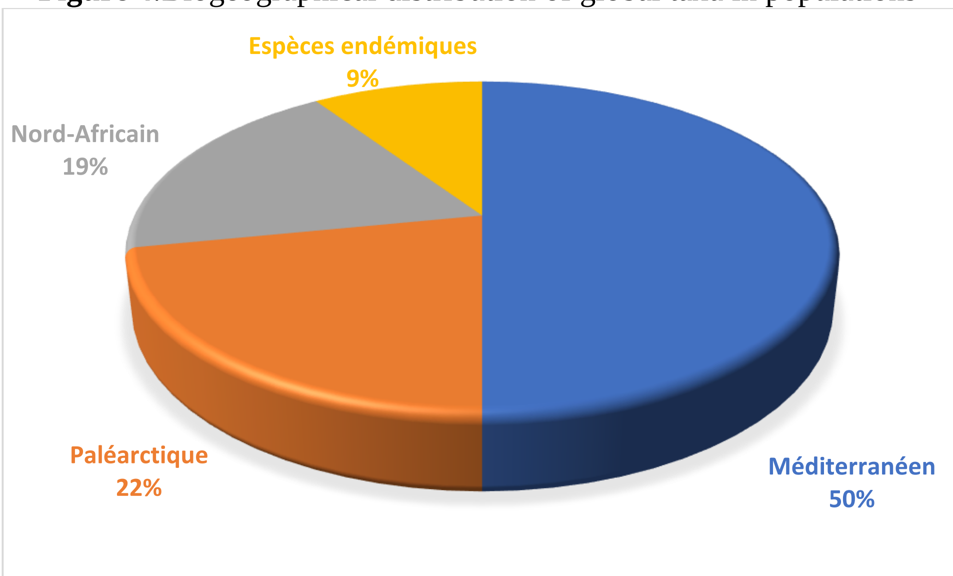

Figure 5:Biogeographical distribution spectrum of all Carabidspecies in the study area

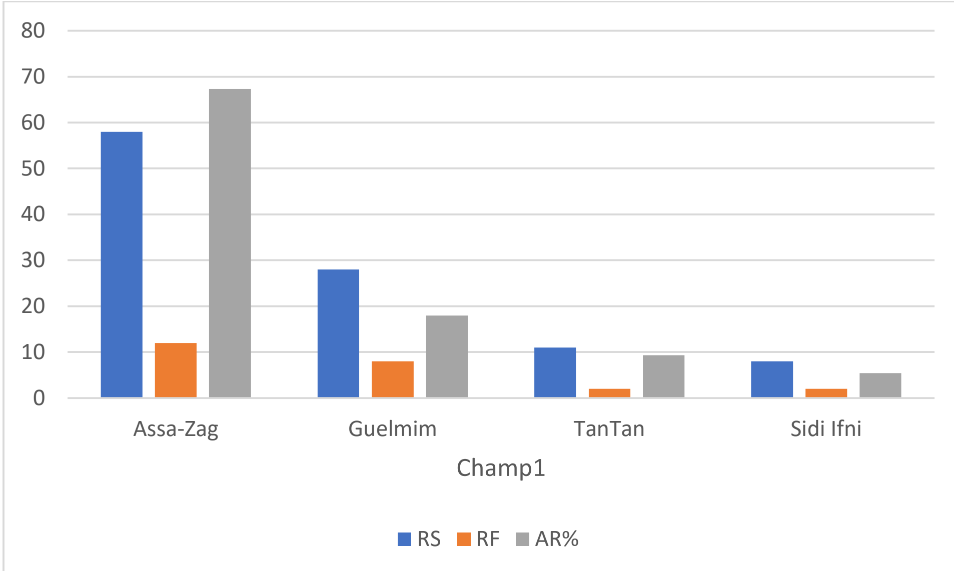

Figure6:Spatial variation of speciesrichness, relative abundance, and familyrichness of beetles. RF: Family Richness, SS: SpecificRichness, RA: Relative Abundance

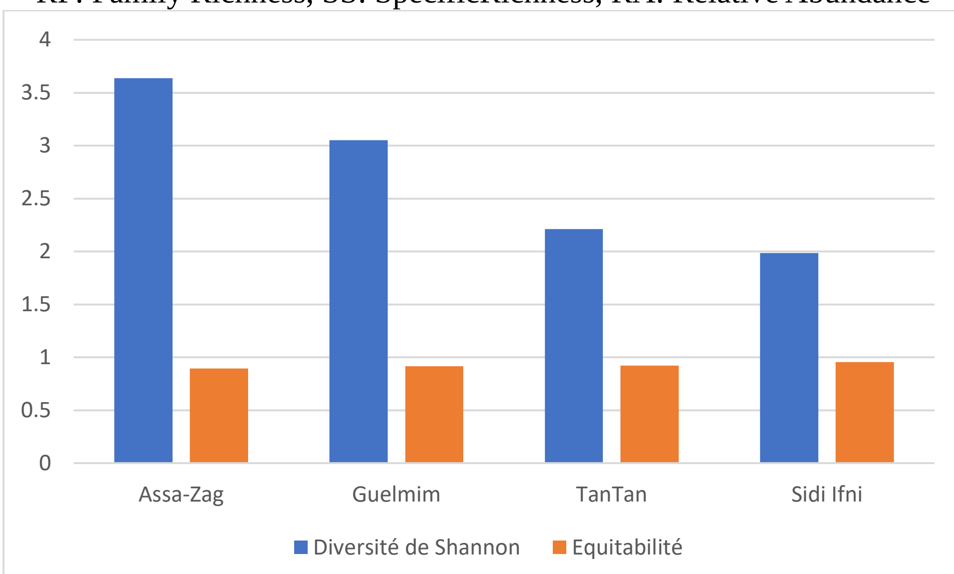

Figure7:Variation of the Shannon-Weiner (H) and Evenness (E) indices in the four study zones

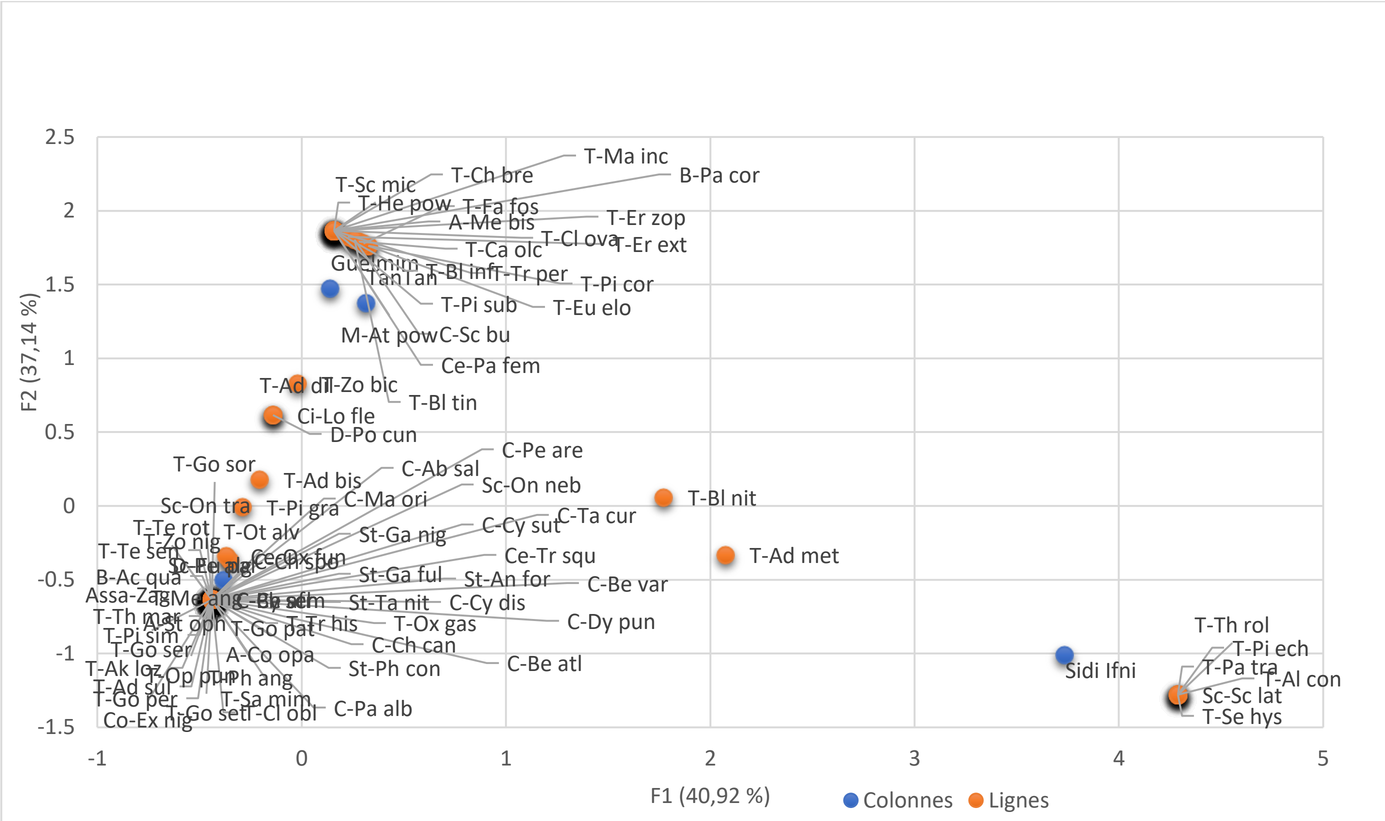

Figure 8: Ordination of species and stations along axes F1 and F2 of the CorrespondenceAnalysis (CA). Appendix 1 provides the significance of the abbreviationsused to represent the two axes, F1 and F2.

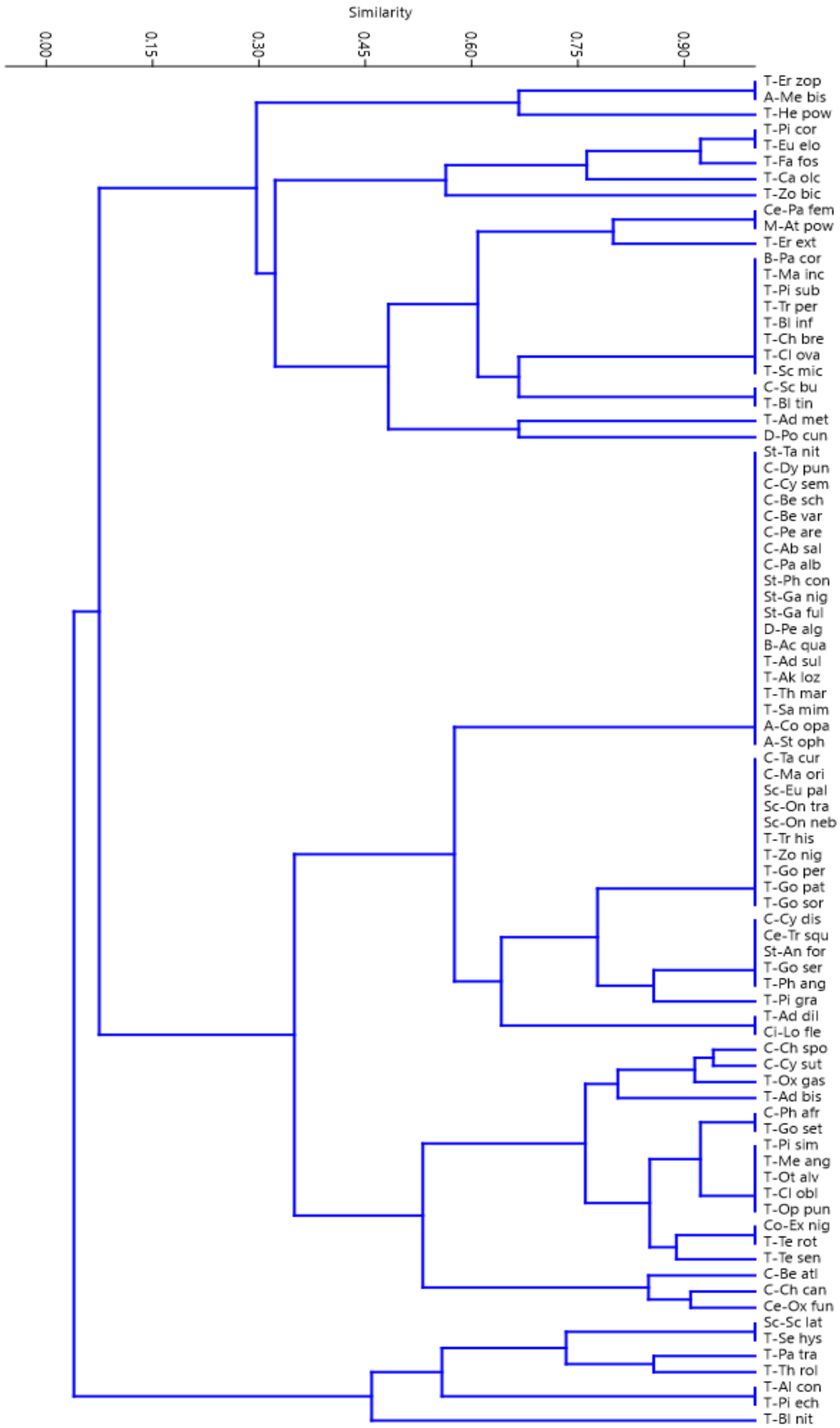

Figure 9 :Dendrogram of species in the four stations, based on Sorensen'sanalysis. Appendix A provides the meanings of the abbreviations..