TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

22.2

The Wetlands Diversity

Editors

Angela Curtean-Bănăduc & Doru Bănăduc

Sibiu – Romania
2020

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"*Lucian Blaga*" University of Sibiu,
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International Association for Danube Research

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Sibiu – Romania
2020

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IN MEMORIAM

Herbert Spencer
(1820 – 1903)

Herbert Spencer was an English biologist, anthropologist, sociologist, philosopher, and distinguished classical liberal political thinker of the Victorian period.

He was born in Derby, England, on the 27th of April 1820. Spencer's father introduced him to science while the members of the Derby Philosophical Society introduced him to pre-Darwinian ideas of biological evolution, with emphasis on work done by Erasmus Darwin and Jean-Baptiste Lamarck. One of Spencer's uncles taught him mathematics, physics, and Latin but in general he was an autodidact that collected most of his wisdom from readings and conversations.

Spencer found it hard to settle on any scholarly or professional area. He worked as an engineer, as an author, and editor for different journals.

He advanced the exhaustive idea of evolution as the continuous progress of the physical world, biological organisms, the human mind, and culture. As a gifted person, he contributed to a large range of subjects: ethics, religion, anthropology, economics, political theory, philosophy, literature, astronomy, biology, sociology and psychology. Throughout his life Spencer achieved exceptional authority, mainly in the context of the academia.

He was one of the most illustrious European intellectuals in the closing decades of the nineteenth century, but his importance declined after 1900.

He presented his evolutionary viewpoint for the first time in his essay, "Progress: Its Law and Cause" (1857), which formed after the basis of the "First Principles of a New System of Philosophy" (1862). In it he explains the theory of evolution with a generalization of the law of embryological evolution. *Spencer* hypothesized that all structures in the cosmos evolve from an 'uncomplicated, undifferentiated, homogeneity to a complex, differentiated, heterogeneity, while being accompanied by a process of higher integration of the separate elements'. This evolutionary process could be identified at work, *Spencer* concluded, in all of the cosmos. It was a comprehensive law that was relevant to the stars and the galaxies as much as to biological organisms; to human social organisation as much as to the human mind. It contrasts from other scientific theories only by its higher generality.

Spencer is especially known for the remark "survival of the fittest", which he created in Principles of Biology (1864), after reading Charles Darwin's *On the Origin of Species*. This phrase firmly advocates for natural selection, and yet as *Spencer* extended the evolution concept into the realms of sociology and ethics, he also used the Lamarckism.

Spencer, in his book Principles of Biology (1864), proposed a pangenesis theory that included "physiological units" assumed to be analogous to specific body parts and responsible for the transmission of typical features to descendants. These hypothetical hereditary elements were very much alike to Darwin's gemmules.

Spencer's works were translated into many languages and he was offered honours and awards throughout Europe and North America.

He continued formulating questions all his life, trying to give answers, writing, in later years often by dictation, until he succumbed to poor health at the age of 83.

The Editors

Transylvanian Review of Systematical and Ecological Research

22.2 The Wetlands Diversity ***2020***

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Preface

In a global environment in which the climate changes are observed from few decades no more only through scientific studies but also through day by day life experiences of average people which feel and understand allready the presence of the medium and long-term significant change in the “average weather” all over the world, the most comon key words which reflect the general concern are: heating, desertification, rationalisation and surviwing.

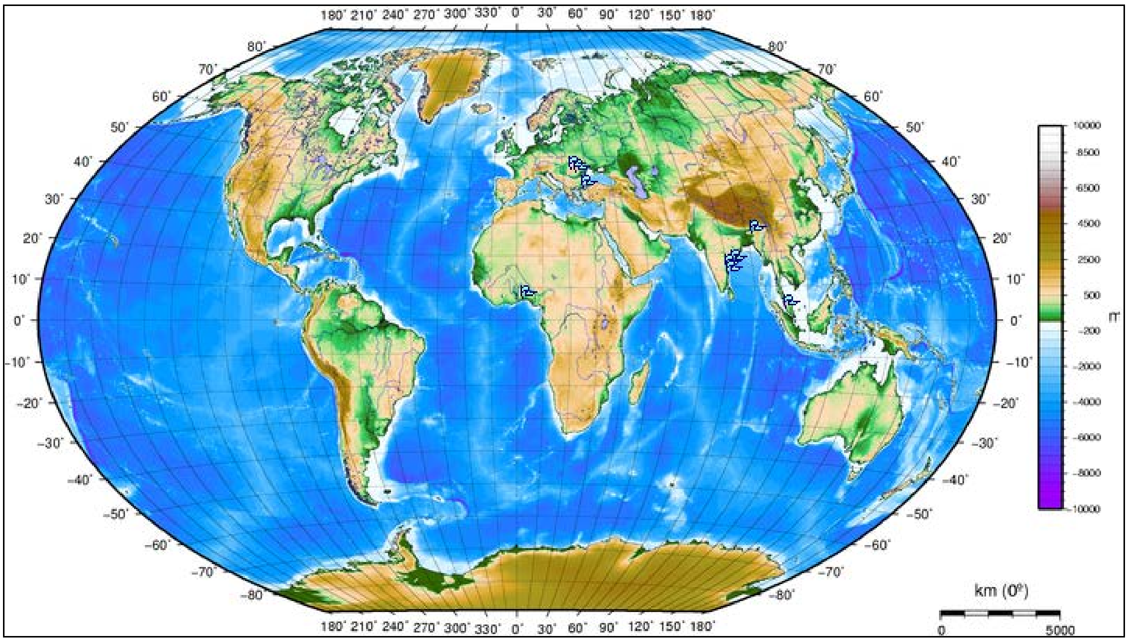
The causes, effects, trends and possibilities of human society to positively intervene to slow down this process or to adapt to it involve a huge variety of aproacess and efforts.

With the fact in mind that these aproaces and efforts shuld be based on genuine scientific understanding, the editors of the *Transylvanian Review of Systematical and Ecological Research* series launch three annual volumes dedicated to the wetlands, volumes resulted mainly as a results of the *Aquatic Biodiversity International Conference*, Sibiu/Romania, 2007-2017.

The therm wetland is used here in the acceptance of the Convention on Wetlands, signed in Ramsar, in 1971, for the conservation and wise use of wetlands and their resources. **Marine/Coastal Wetlands** – Permanent shallow marine waters in most cases less than six metres deep at low tide, includes sea bays and straits; Marine subtidal aquatic beds, includes kelp beds, sea-grass beds, tropical marine meadows; Coral reefs; Rocky marine shores, includes rocky offshore islands, sea cliffs; Sand, shingle or pebble shores, includes sand bars, spits and sandy islets, includes dune systems and humid dune slacks; Estuarine waters, permanent water of estuaries and estuarine systems of deltas; Intertidal mud, sand or salt flats; Intertidal marshes, includes salt marshes, salt meadows, saltings, raised salt marshes, includes tidal brackish and freshwater marshes; Intertidal forested wetlands, includes mangrove swamps, nipah swamps and tidal freshwater swamp forests; Coastal brackish/saline lagoons, brackish to saline lagoons with at least one relatively narrow connection to the sea; Coastal freshwater lagoons, includes freshwater delta lagoons; Karst and other subterranean hydrological systems, marine/coastal. **Inland Wetlands** – Permanent inland deltas; Permanent rivers/streams/creeks, includes waterfalls; Seasonal/intermittent/irregular rivers/streams/creeks; Permanent freshwater lakes (over eight ha), includes large oxbow lakes; Seasonal/intermittent freshwater lakes (over eight ha), includes floodplain lakes; Permanent saline/brackish/alkaline lakes; Seasonal/intermittent saline/brackish/alkaline lakes and flats; Permanent saline/brackish/alkaline marshes/pools; Seasonal/intermittent saline/brackish/alkaline marshes/pools; Permanent freshwater marshes/pools, ponds (below eight ha), marshes and swamps on inorganic soils, with emergent vegetation water-logged for at least most of the growing season; Seasonal/intermittent freshwater marshes/pools on inorganic soils, includes sloughs, potholes, seasonally flooded meadows, sedge marshes; Non-forested peatlands, includes shrub or open bogs, swamps, fens; Alpine wetlands, includes alpine meadows, temporary waters from snowmelt; Tundra wetlands, includes tundra pools, temporary waters from snowmelt; Shrub-dominated wetlands, shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils; Freshwater, tree-dominated wetlands; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils; Forested peatlands; peatswamp forests; Freshwater springs, oases; Geothermal wetlands; Karst and other subterranean hydrological systems, inland. **Human-made wetlands –** Aquaculture (e. g., fish/shrimp) ponds; Ponds; includes farm ponds, stock ponds, small tanks; (generally below eight ha); Irrigated land, includes irrigation channels and rice fields; Seasonally flooded agricultural land (including intensively managed or grazed wet meadow or pasture); Salt exploitation sites, salt pans, salines, etc.; Water storage areas, reservoirs/barrages/dams/impoundments (generally over eight ha); Excavations; gravel/brick/clay pits; borrow pits, mining pools; Wastewater treatment areas, sewage farms, settling ponds, oxidation basins, etc.; Canals and drainage channels, ditches; Karst and other subterranean hydrological systems, human-made.

The editors of the *Transylvanian Review of Systematical and Ecological Research* started and continue the annual sub-series (*Wetlands Diversity*) as an international scientific debate platform for the wetlands conservation, and not to take in the last moment, some last heavenly “images” of a perishing world …

This volume included variated original researches from diverse wetlands around the world.



The subject areas ( ) for the published studies in this volume.

No doubt that this new data will develop knowledge and understanding of the ecological status of the wetlands and will continue to evolve.

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The editors would like to express their sincere gratitude to the authors and the scientific reviewers whose work made the appearance of this volume possible.

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SUSPENDED SEDIMENT CONCENTRATION AND SEDIMENT LOADING OF BERNAM RIVER (PERAK, MALAYSIA)

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KEYWORDS: suspended sediment, sediment loading, sediment yield, Bernam River, Malaysia.

ABSTRACT

This paper presents some of our preliminary results on the sediment discharge and load based on weekly sampling starting from Oct 2017 to January 2018. Results show that sediment rating curve of Bernam River was R^2 = 0.86 high flow and R^2 = 0.5 low flow. Average sediment loading throughout this sampling period is 1,144 t. Land use activity is expected to be the main contribution for the highest sediment concentration during rain events. The amount of annual sediment yield was estimated at 23 t/km^2/year and is comparable to other studies having similar land uses in the catchment area.

RÉSUMÉ: Concentration des sédiments en suspension et charge sédimentaire de la rivière Bernam (Perak, Malaisie).

Cet article présente certains de nos résultats préliminaires sur le déchargement et la charge de sédiments, basés sur un échantillonnage hebdomadaire commencé entre octobre 2017 et janvier 2018. Les résultats montrent que la courbe de cotation des sédiments de la rivière Bernam était R^2 = 0,86 en débit élevé et R^2 = 0,5 en débit faible. La moyenne de la charge sédimentaire tout au long de cette période d'échantillonnage est de 1.144 t. On s'attendait à ce que l'activité d'utilisation des terres soit la principale contribution à la plus forte concentration de sédiments pendant les épisodes de pluie. La quantité de sédiments produits annuellement a été estimée à 23 t/ km^2/an et est comparable à d'autres études portant sur des utilisations similaires des terres dans le bassin versant.

REZUMAT: Concentraţia sedimentului suspendat şi încărcătura în sediment a râului Bernam (Perak, Malaezia).

Această lucrare prezintă câteva dintre rezultatele noastre preliminare privind evacuarea şi încărcarea de sedimente bazate pe prelevări săptămânale începute în octombrie 2017 până în ianuarie 2018. Rezultatele arată faptul că, curba de evaluare a sedimentelor râului Bernam a fos R^2 = 0.86 la debite ridicate şi R^2 = 0.5 la debite scăzute. Media încărcării cu sediment pe parcursul acestei perioade de prelevare este de 1.144 t. Activităţile de utilizare a terenurilor a fost de aşteptat să fie cauza principală pentru cea mai mare concentraţie de sediment din timpul ploilor. Cantitatea anuală de sediment a fost estimată la 23 t/km^2/an şi este comparabilă cu cea a altor studii cu tipuri similare de utilizări de terenuri în bazinul de captare.

INTRODUCTION

Soil erosion is a world-wide phenomenon caused by natural agents. It is accelerated due to human activities and induced by socioeconomic development over years (Poons, 2008; Isaka and Ashraf, 2017). Soil erosion is a process of moving soil by water or wind and this is a natural process that has occurred for eons of time.

Erosion consists of three processes: detachment (from the ground), transportation (water or wind), and deposition. The deposition occurs often in places we don't want the soil such as streams, lakes, reservoirs, or deltas (Liu, 2016). A major concern with deposition is that the topsoil, which is often the most fertile for agricultural use, erodes away and exposes the subsoil, which is less productive. This process may pose a threat to sustained agricultural production (Li and Wei, 2011).

The eroded material from soil erosion may cause both on-site and off-site effects which are detrimental to ecosystem and environment as well (Parsons and Cooper, 2015). Massive soil erosion hinders the growth of plants, agricultural yields, water quality, catchment health, and recreation (Pimentel and Burgess, 2013). It can cause of degradation of soils as it occurs naturally on all lands (Ding et al., 2015; Posthumus et al., 2015).

The causes of soil erosion are basically water and wind, with each of these contributing to a significant level of annual soil loss (Ding et al., 2015). Soil erosion is a problem in areas with expanding population, agricultural production, construction, and urbanization as well as human activities. (Ding et al., 2015) Among the factors that cause soil erosion is poor land management which causes damages to the soil and results in water runoff across landscapes instead of adequate infiltration (Niu et al., 2015; Liu, 2016).

Water quality issues have brought a daunting task for water environment management; the spatial temporal differences of water quality could provide dynamic information for the decision-maker of water environment (Al-Wadaey and Ziadat, 2014).

Suspended load and suspended sediment are very similar but are not the same. Fine sediment can be found in nearly any body of water, carried along by the water flow. When the sediment is floating within the water column it is considered suspended. Suspended sediment contains sediment that is uplifted into flowing water. The sediment is kept suspended as long as there are flow velocities that transport the sediment above the bed. With low velocity the sediment will be deposited. Excessive transport or sediments such as silt, sand and gravel in rivers can cause problems for flood control, soil conservation, irrigation, aquatic health, etc. Erosion from land surface, bank erosion, and channel bed load contribute to the amount of sediment entering to the stream. Suspended sediment comes from turbulent currents and movement of coarser particles along the streambed. (Parsons and Cooper, 2015)

The aim of this study was to investigate the variation of suspended sediment concentration and suspended sediment loading, and estimate annual sediment load and yields of Bernam River.

The results of this research can support the building of an integrated conservation management system plan for the Bernam River watershed, such that the sediments effects on the aquatic habitats can be treated as a core issue, in the circumstances in which erosion and sedimentation do not negatively effect this lotic system natural resources and can offer optimum natural services.

The optimum reduction of sediment negative effects on the researched aquatic habitats will appear only if the conservation management system will be approached and planed finally for the whole Bernam Basin.

MATERIAL AND METHODS

Study area. Bernam River located in the south part of Perak and northeast Selangor, Malaysia located between N 03° 40' 45'' to E 101° 31' 20'' (Figs. 1-4). The catchment in the study area was 186 km^2 and the elevation above mean sea level is 41 m. The maximum length and breadth of the catchment area are 21 km and 14 km, respectively. (DID, 1986)

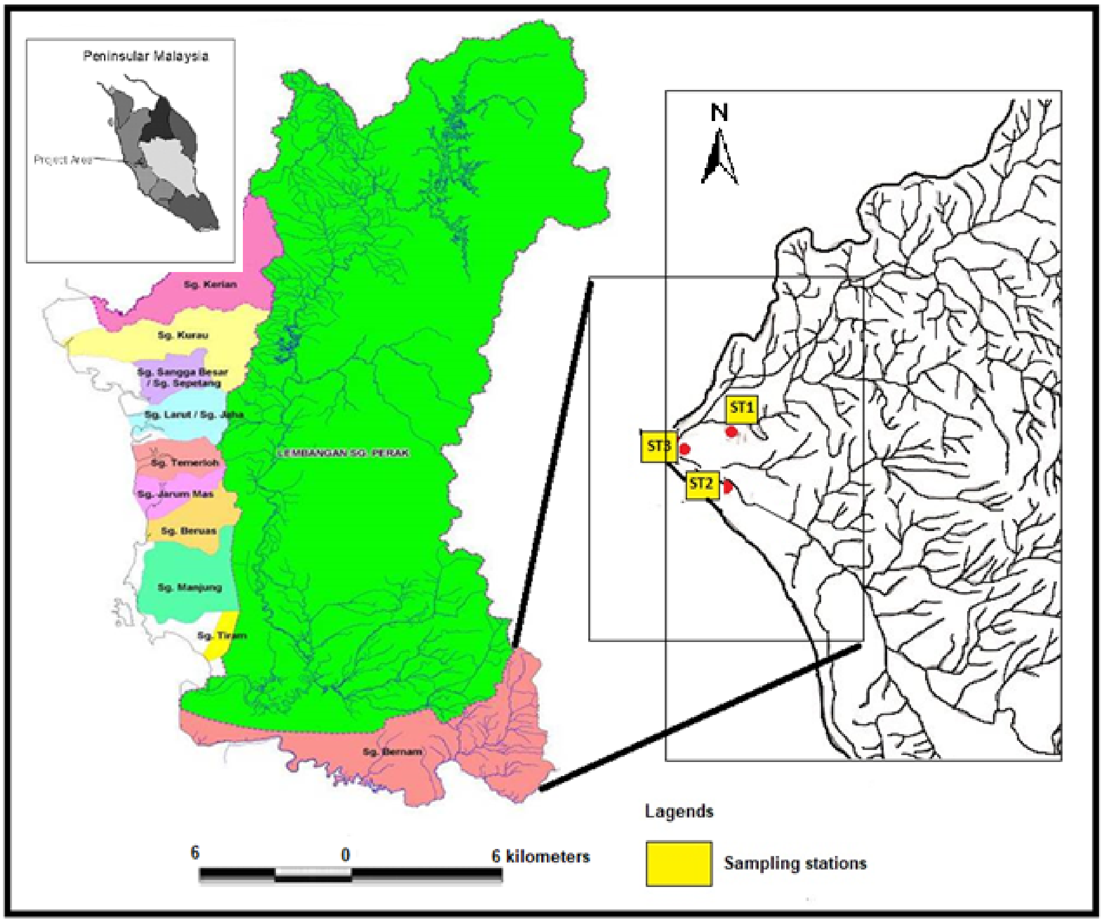

Figure 1: Bernam River Catchment Area location map.

About 78% of this catchment consists of steep mountainous country rising to heights of 1,830 m while the remainder is hilly country. The mountainous areas are under jungle, while the hilly undulating areas are mainly under mixed forest and rubber plantation. The majority of the catchment has a granitic soil cover consisting of fine to coarse sand and clay. The depth of the cover is generally only a few metres, but greater depths may be encountered in areas of intense weathering. A small portion in the south has a variable soil cover consisting of sandy loam grading to clay loam. The depth of alluvium in the valleys is between 8 to 15 m. Strike of sediments is approximately northwest to southeast with dip, varying between 45° to 65°, towards northeast and southwest. It is also a source of irrigation and water supply for 20,000 ha rice granary and eco-tourism activities for local people. (DID, 1986)

Figure 2a: Low flow of Bernam River at station 1.

Figure 2b: High flow of Bernam River at station 1.

Figure 3a: Low flow of Bernam River at station 2.

Figure 3b: High flow of Bernam River at station 2.

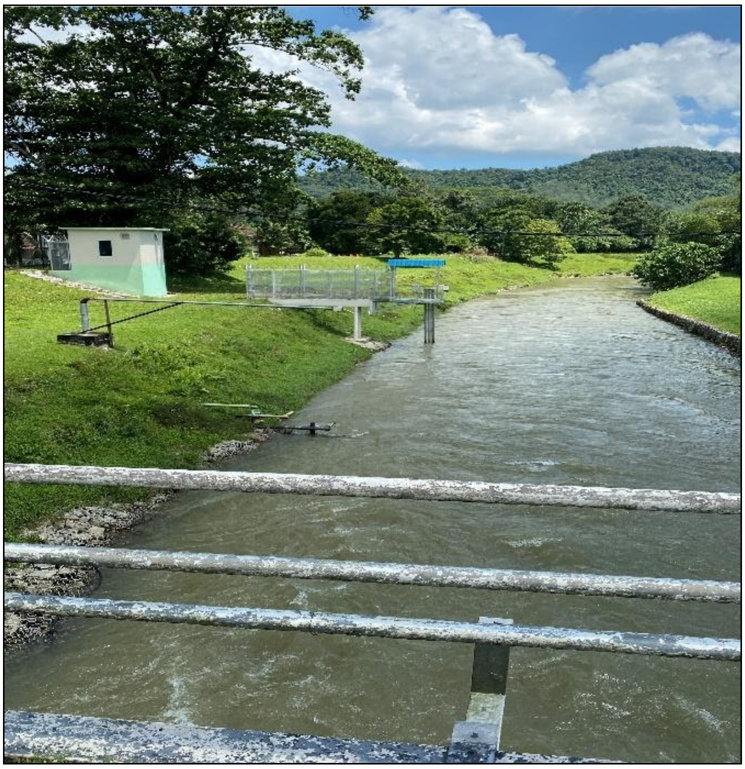

Figure 4a: Low flow of Bernam River at station 3.

Figure 4b: High flow of Bernam River at station 3.

Tanjung Malim Perak area near at Titiwangsa Range received high amount of rainfall. Annual rainfall in the study area was 2,600 mm in 2017. Land-use in Bernam catchment in 2004 is mainly forest (47.7 %), rubber (14.8%), oil palm (25.9%), shrub (7%), built up area (3%) and 1.5% water body (Che Ngah et al., 2014).

Table 1 describes the location of the three sampling stations. These stations were chosen due to their accessible monitoring during the storm events.

Table 1: Sampling station in the downstream areas.

Station	River	Latitude	Longitude
1	Bernam River	3º68'14.5"N	101º53'04.9"E
2	Inki River	3º57'42.4"N	101º52'85.7"E
3	Bernam River	3º67'81.9"N	101º52'08.4"E

Discharge. River flow was measured using propeller current meter and discharge was calculated using a velocity-area method (Grdon, 1992). Discharge in the main inlets and the outlets was measured and the water level were recorded continuously. The cross-sectional view of each station was plotted on graph paper using the width and depth measurements obtained in the field to obtain cross-sectional area of flow. All statistical and data analysis were conducted in Microsoft Excel and SPSS. The discharge at each station was then estimated by the velocity area method using the relation:

Q = AV where: Q = discharge ($m^3 \cdot s$-1) V = mean velocity (m·s-1) A = area of cross-section (m^2) (Schumm, 1977; Ismail and Najib, 2011).

Calculation of sediment loading. The suspended sediments concentrations were then used to estimate the sediment load in the water at a given time at each station since the suspended load is the product of concentration and discharge, as follows:

Qs = QC where: Qs = Suspended load ($g \cdot s^{-1}$) Q = discharge ($m^3 \cdot s^{-1}$) C = concentration ($g \cdot m^{-3}$) (Bourne and Jones, 2002).

RESULTS AND DISCUSSION

Rainfall.

Tropical climate of Malaysia received high amounts of rainfall with an average 2,000-3,000 millimetres per year. The rain is also caused by monsoon regime, and there are two types of monsoons; Southwest Monsoons (May-September) and Northeast Monsoons (November-March) (Wilson, 1990). Monsoons make precipitation more abundant and frequent in some area. For example, when East coast monsoon occur, the eastern part of Peninsular Malaysia is affected by the rainy season in November and December and can exceed 500 mm per month. December is the rainiest month for the east coast area. During the El Nino event, Malaysia also experienced a substantial decrease in rainfall (Kamil and Omar, 2017). Based on data from Drainage and Irrigation Department Malaysia (Fig. 5), an average of 17 years of rainfall station at Bernam River at Tanjung Malim Perak from 2000 to 2017. Based on the annual rainfall data, the highest rainfall was recorded in 2006 (3,516 mm/year) while the lowest rainfall data was recorded in 2006 (1,535 mm/year). The highest average rainfall for 17 years was in November and April due to the monsoon regime. Soil erosion usually occurs in places that are susceptible, where the topography is sloped and when long duration rainfall coincides with inadequate vegetative cover (Thomas, 1985; Isaka and Ashraf, 2017).

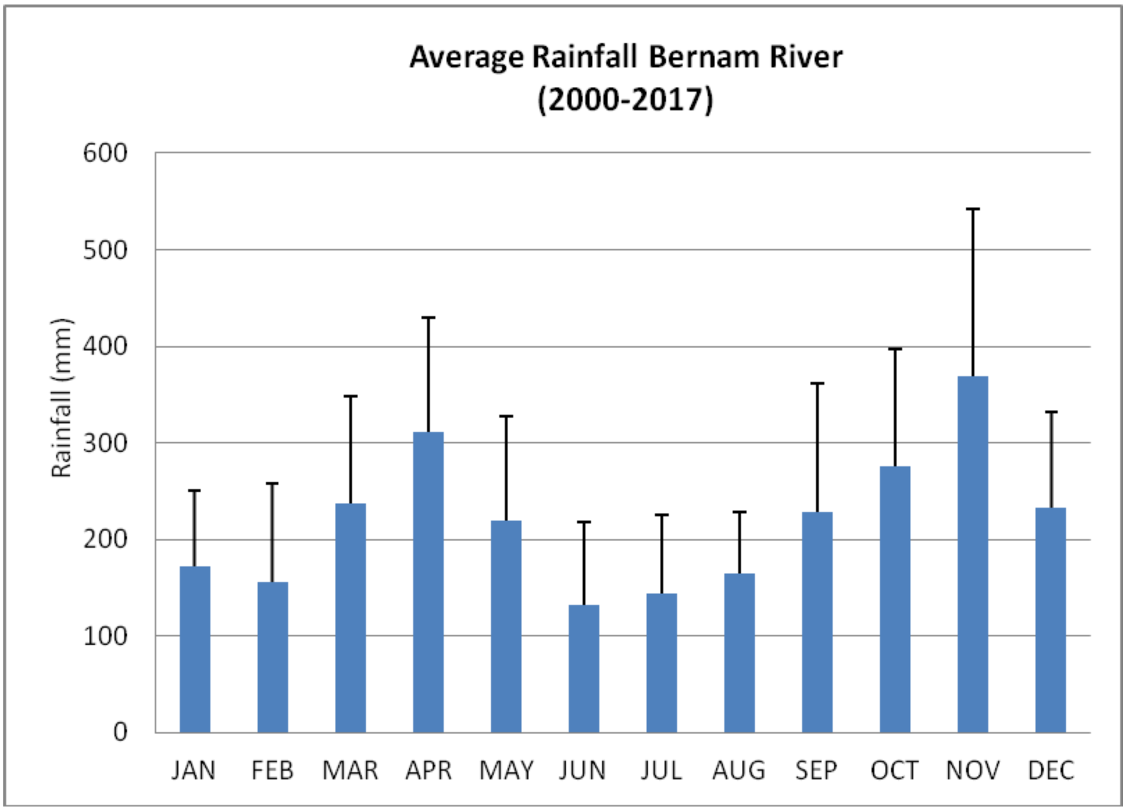

Figure 5: Average monthly rainfall of Bernam River at Tanjung Malim from 2000-2017.

Suspended sediment concentrations. Suspended sediment is defined as material that is kept in suspension by the upward components of turbulent currents or it may exist in suspension as a colloid. The SSC is the velocity weighted concentration of suspended sediment in the sampled zone, expressed as milligrams of dry sediment per litre of water-sediment mixture. Suspended sediment concentration has been used as a measure of fluvial sediment (Parsons and Cooper, 2015). The high amount of suspended sediment indicates that the soil erosion is serious in the watersheds (Thomas, 1985; White, 2005). Figure 6 showed weekly data from October 2017 until January 2018. The highest concentration is 128 mg/L in 11 December 2017 and the lowest concentration is on 19 November 2017 with only 8 mg/L concentration. Based on land-use of Bernam catchment, sediment contribution is come from agricultural and human activities in the catchment area. Sediment rating curve is a relationship between sediment concentration and discharge. Rating curves are used to calculate or predict a variable that is difficult to measure continuously (Willis, 2011). Discharge measurement must be made for at least three different water surface elevations such as low flow, median flow and high flow (James and James, 2017). For this study area, the regression of discharge and SSC is R^2=0.86 high flow sampling while for low flow sampling the regression is R^2=0.5. Best-fit regression lines represent the relation between SSC and discharge and can be used to evaluate how SSC responds to changes in discharge. The gradient of the lines provides an indication of how quickly SSC changes with changes in discharge. Lines with steep positive gradients from left to right indicate SSC increases quickly as discharge increases. Figure 6 shows the low flow and high flow and contribute to the high concentration of suspended sediment and turbidity.

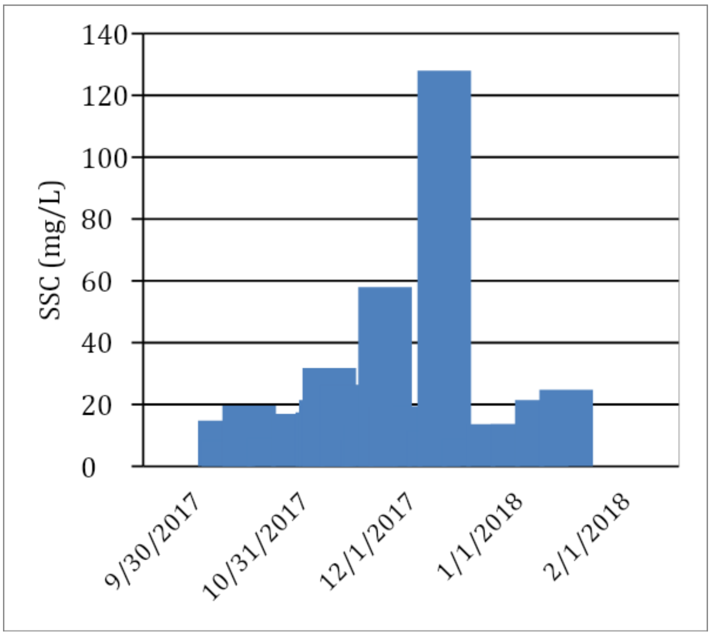

Figure 6a: Temporal variation of rainfall and suspended sediment concentration (SSC), and the relationship between SSC versus Discharge during low flow and high flow condition.

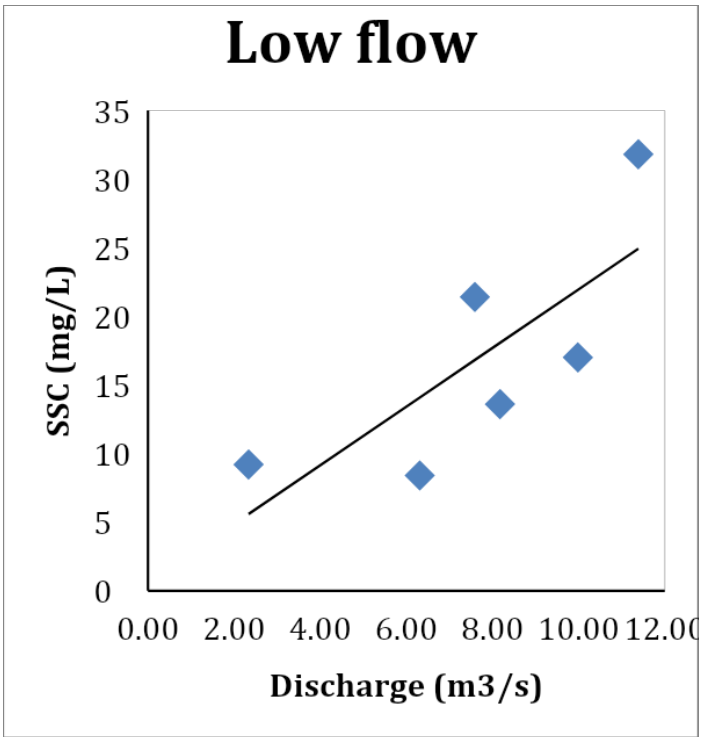

Figure 6b: Temporal variation of rainfall and suspended sediment concentration (SSC), and the relationship between SSC versus Discharge during low flow and high flow condition.

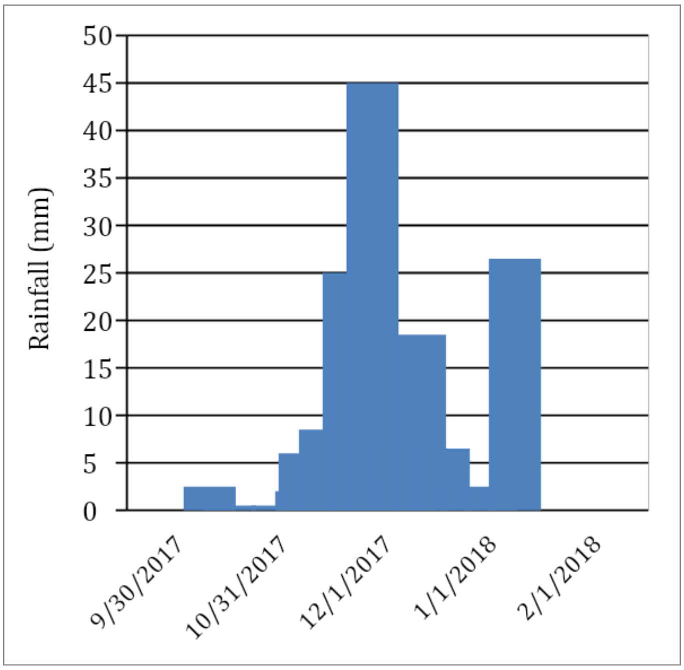

Figure 6c: Temporal variation of rainfall and suspended sediment concentration (SSC), and the relationship between SSC versus discharge during low flow and high flow condition.

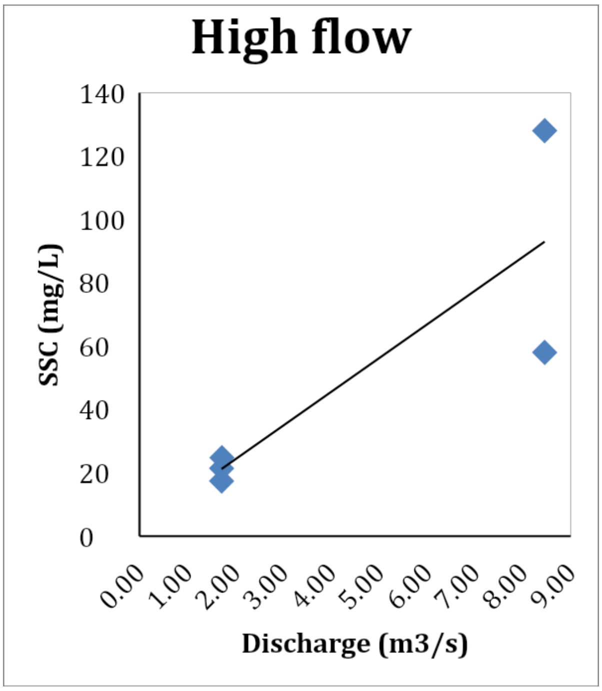

Figure 6d: Temporal variation of rainfall and suspended sediment concentration (SSC) during study period, and the relationship between SSC versus Discharge during low flow and high flow condition.

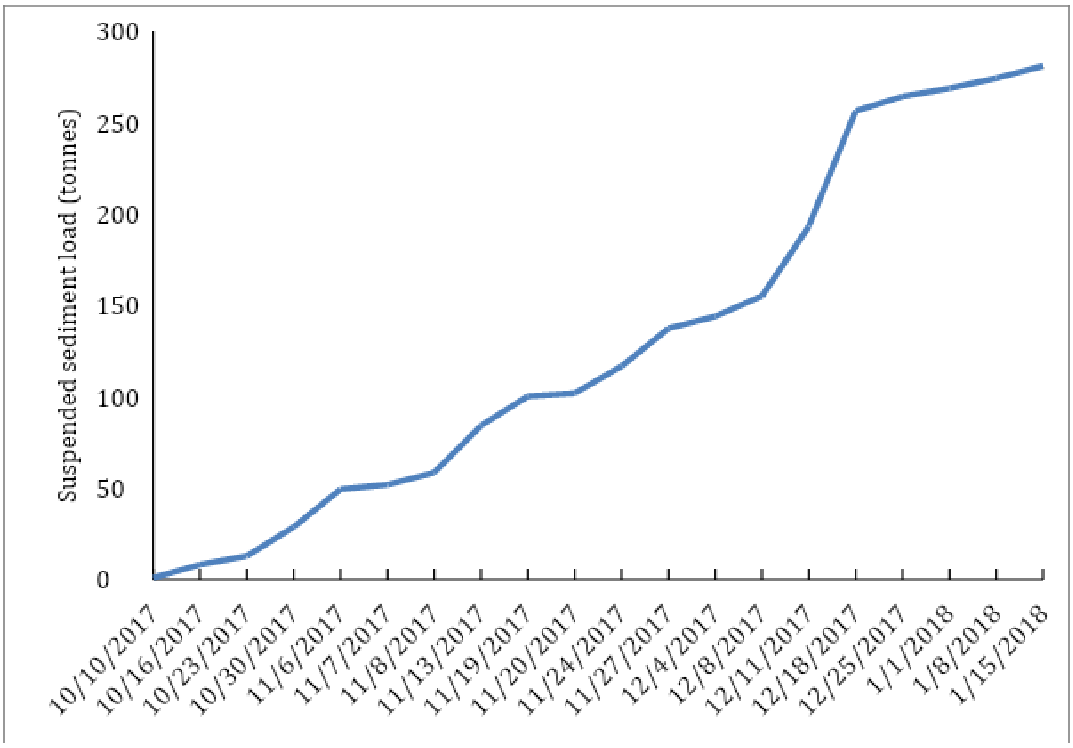

Figure 7: Cummulative of Sediment loading in Bernam River.

Suspended sediment loading and yields. The nature of water is never totally clear, especially in surface waters, such as rivers and lakes. Water has colour and some extent of dissolved and suspended material, usually dirt particles (suspended sediment). Suspended sediment is an important factor in determining the quality of water. In fact, so much sediment is carried during storms that over one-half of all the sediment moved during a year might be transported during a single storm period. Suspended sediment is defined as material that is kept in suspension by the upward components of turbulent currents or that exists in suspension as a colloid. The SSC is the velocity weighted concentration of suspended sediment in the sampled zone, expressed as milligrams of dry sediment per litre of water-sediment mixture.

Suspended sediment concentrations have been used as a measure of fluvial sediment. The high amount of suspended sediment indicates that the soil erosion is serious in the watersheds (White, 2005). Sediment loading is one of the parameters that show the high concentration of sediment in the catchment area. Loadings of suspended sediment between time intervals were calculated by multiplying the discharge Q (m^3 s^{-1}) by concentration S (mg L^{-1}) over the time interval K (s) between samples, based on the average sample load approach (Littlewood, 1992). All statistical and data analysis were conducted in Microsoft Excel. In order to get annual data, estimations can be made from 98 days sampling from this study. Based on this study, sediment load for Bernam River is 1,144 t and estimated sediment load per year is 4,264 t. Cumulative sediment loading is shown in Figure 5. Sediment yield (given as t per year) can be defined as the amount of sediment reaching in the catchment (White, 2005). The importance of study sediment yields is to understand and be aware of how much sediment is deposited in the catchment (Najib et al., 2017). Based on this study, estimation of sediment yields is 22.9 t/km^2/year. Land-use type of Bernam, with the mountainous area under jungle, may contribute to low amount of sediment yield in comparison to other studies in forested catchments, such as Kalangan River, where the sediment yields was 15.5 t/km^2/year (Sinun et al., 1992), Tekam River yielded 29 t/km^2/year (DID, 1986), Bukit Berembun yielded 20 t/km^2/year (Baharuddin, 1988). From 1984 to 2020, land-use pattern in the Bernam area had undergone obvious transformations (Alasi et al., 2009; Che Ngah et al., 2014). The proportion of area under urban and oil palm increased, and the proportion of rubber and forest reduced. The change of land-use pattern has altered the runoff amount in the area. In the year 2020, predicted runoff has been increased in the rainy season due to large increase of land use changes especially in urban and forest areas, which then accelerate runoff and decrease base flow due to an increase in the impervious area.

CONCLUSIONS

In accordance to sediment study in Bernam catchment area, we suspect that main contributor came from the land-use activities in the catchment. Rainfall event is the driver of the erosion process causing the contribution of the amount of sediment discharged out of the basin. During the course of this three month study, we found that sediment loading for Bernam River amounted to 1,144 t, and this is equivalent to an annual loading of 4,264 t/year. The amount of annual sediment yield was estimated at 23 t/km^2/year and is comparable to other studies in the region that consist of more forested area in the catchment.

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SEDIMENTS AS FACTOR IN THE FATE OF THE THREATENED ENDEMIC FISH SPECIES *ROMANICHTHYS VALSANICOLA* DUMITRESCU, BĂNĂRESCU AND STOICA, 1957 (VÂLSAN RIVER BASIN, DANUBE BASIN)

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ABSTRACT

The main emphasis of this paper is on the negative effects of sedimentation on the most highly endangered fish of Europe *Romanichthys valsanicola* and the habitats of its main trophic resource *Rhithrogena semicolorata*. Some inexpensive and easy-to-implement solutions are identified and proposed (dam reservoir related recommendations for basin sediments management, forestry related recommendations for sediment basin management, basin sediments general management recommendations, riverbed ecological reconstruction approach proposal, etc.) in the paper with the same conservative purpose for *Romanichthys valsanicola* species in the actual situation of habitat loss and drastic regress of this globaly-unique fish population.

RÉSUMÉ: Impact du facteur sédimentaire sur l'espèce endémique et menacée de poisons *Romanichthys valsanicola* Dumitrescu, Bănărescu and Stoica, 1957 (Vâlsan River basin, Danube Basin).

Dans cet article l'accent se porte sur le phénomène de sédimentation trop important, qui a un impact négatif sur l'espèce de poissons la plus menacée d'Europe *Romanichthys valsanicola* mais également sur l'habitat de sa principale ressource trophique *Rhithrogena semicolorata*. Quelques solutions faciles à mettre en place et peu couteuses ont été identifiées et proposées (recommandation concernant les lacs formés par des barrages pour la gestion des sédiments, recommandation concernant la sylviculture pour la gestion des sédiments, proposition d'approche pour la reconstruction écologique des lits de rivières, etc.) dans l'article avec le même objectif afin de conserver *Romanichthys valsanicoa* une espèce unique fortement menacée du fait de la réduction de son habitat naturel et sujette à une diminution forte et globale de sa population.

REZUMAT: Sedimentele ca factor în soarta speciei endemice ameninţate de peşte *Romanichthys valsanicola* Dumitrescu, Bănărescu şi Stoica, 1957 (bazinul râului Vâlsan, bazinul Dunării).

Accentul principal al acestei lucrări este pus pe efectele negative ale sedimentării asupra habitatului celui mai ameninţat peşte al Europei *Romanichthys valsanicola* şi a resursei lui trofice principale *Rhithrogena semicolorata*. Au fost identificate şi propuse unele soluţii ieftine şi uşor de implementat (recomandări legate de managementul sedimentelor lacului de baraj, recomandări silvice legate de managementul sedimentelor din bazin, recomandări generale de management a sedimentelor din bazin, propunerea unor elemente de reconstrucţe ecologică, etc.), cu acelaşi scop de conservare a speciei *Romanichthys valsanicoa* în situaţia pierderii habitatului şi de regres drastic al acestei populaţii de peşti unici la nivel global.

INTRODUCTION

Mid-20th-century Europe: this continent with so many of the most prestigious schools of natural sciences of the world, considered the inventory of biodiversity "at home" was thoroughly well known enough such that the scrutiny of European specialists focused their continuous and vigorous professional competition in the natural sciences to the continents of Africa, Asia, South America, Australia, and Antarctica. As always, one of the most attractive prizes for the academic community, which brings great satisfaction and professional recognition, is that opportunity of scientific pioneering, the discovery of a new species! (Bănăduc, 2004)

The genus *Romanichthys*, with its only species *Romanichthys valsanicola* Dumitrescu, Nalbant and Dragomirescu, 1957 (Dumitrescu et al., 1957), was discovered only recently, however, in 1956 by Stoica M., in the Vâlsan River (terra typica), a tributary of the Argeş River/Danube Basin, on Romanian Galeş Commune territory (Bănărescu, 1964, 2005; *, 1999-2003).

The discovery of this genus and species came as a big surprise to ichthyologists in Europe and North America. The interest shown to *R. valsanicola* is due to its resemblance to a group of exclusively North American genera (Etheostomatini) from the Percidae family. Between 1957 and 1962, this fish was found in the Argeş River, where it was more numerous than in its tributary the Vâlsan (Bănărescu, 1964, 2005; *, 1999-2003). Rumors of its possible occurence in other rivers, however, were never confirmed (Bănărescu and Vasiliu-Oromulu, 2004).

R. valsanicola is a relatively small fish species (12.5 cm total length, 10.5 cm length without the caudal fin) and critically endangered (IUCN, 2008) in spite of its protection status (Bănărescu et al., 1957, 1995; *, 1999-2003; Bănărescu, 2005; Bănărescu and Bănăduc, 2007). This post-glacial relict fish species has the smallest living areal in Europe and Asia, and is considered not only the most endangered fish species of the Danube Basin but of all Europe (Maintland, 1991; Bănărescu, 2002).

The Argeş River, together with its affluents, drains the south slope of the Făgăraş Mountains. It gathers waters from a surface of 12,600 km^2 and after 340 km it flows into the Danube River (Constantinescu, 1990).

In 1960-1966, a big concrete dam on the Argeş River was built (Vidraru Dam with a 166 m height, which created water storage with a total volume of 465 bmil. m^3) (Constantinescu, 1990) upstream of the area populated with this fish species. The complex aftereffects of this dam resulted in a significantly modified lotic system, including habitats specific to *R. valsanicola* (*, 1999-2003; Ureche et al., 2007). Also in 1966, a dam was put into use on the Vâlsan River (basin surface 358 km^2, length 84.6 km) upstream from the *R. valsanicola* habitat areas (Truţă et al., 2016). The considerable depletion of water flow left the fish without the necessary ecological flow on the river (*, 1999-2003). In the following years the species was considered extinct, including on the Vâlsan River, however, it was later found again, but in extremely small numbers (*, 1999-2003). Upstream, the Buda and Capra streams, which form the Argeş River, also became significantly impacted by the deficient construction and management of hydro-power plants in the last few decades (Curtean-Bănăduc, 2014).

In 1989 the reservoir on the Vâlsan River was drained, which was just one of the many significant, negative impacts of the poor management of the dam on the Vâlsan River. As a result of draining the reservoir the bottom of the downstream riverbed was covered by a thick blanket of mud, which greatly deteriorated the living conditions of the aquatic organisms of the river including invertebrates and fish. In the same period, a mine shaft was opened very close to the river, just a short distance upstream from the *R. valsanicola* population. Waste was deposited into and near the river with a very bad effect on the water quality (Bănărescu and Vasiliu-Oromulu, 2004). During this period extremely few specimens of *R. valsanicola* were found. Additionally, national and international efforts to hatch and raise the fish in captivity failed, inadequate food (*Tubifex*) being one of the main reason for this failure (*, 1999-2003; Bănărescu and Vasiliu-Oromulu, 2004).

One of the basic assumptions of this paper is that understanding the *R. valsanicola* ecology and its biologically-specific characteristics can give us the chance to identify valuable clues about the key, necessary management elements needed to conserve this highly-threatened species. Highlighting just the watershed sediments issue, for example, demonstrates the effects on aquatic environments is very compex including changes to light penetration, temperature adjustment, electrolytes, organic matter, and last but not least bottom conditions (Ellis, 1936; Barnes and Mann, 1991; Ispas et al., 2020).

R. valsanicola, a small, rheophilous species, usualy lives in the strong currents of cold and clear mountain streams. It is strictly territorial having as central points of reference large boulders, typically sheltering under the same large stone or boulder during the day, and at night leading an active life seeking food (*, 1999-2003; **, 2013).

Between 1948, when the general registration of water flows in Romania began, and 1967, when the dam was built on an upper Vâlsan River section, the annual water flow of this river at the Brădet locality oscillated between two-to-three m^3/sec., occasionally reaching even four m^3/sec. In 1959, however, it dwindled to 1.5 m^3/sec. No flow downstream the dam was allowed. What little flowing water there was came from infiltrations of groundwater and additions from small tributaries downstream the dam. The water flow at Brădet dropped even further to one m^3/sec., then to 0.5 m^3/sec., and in 2000 and 2001, even less than 0.3 m^3/sec. (*, 1999-2003)!

The habit of the local people to collect rocks from the riverbed for construction should also be mentioned here (Bănărescu et al, 1995). This action led to serious repercussions on relatively less-mobile fish species (Ionaşcu and Crăciun, 2009). Now, the big stones are missing and the boulders that remain do not have enough density and dimension for good habitat and often are covered by fine sediments.

The arrangement of the teeth, the pharyngeal area, and the size of the stomach in *R. valsanicola* denotes a carnivorous and voracious species, which feeds on lotic invertebrates. The low ratio of *R. valsanicola* among the local potential trophic competitors *Barbus meridionalis* Risso, 1827, *Cottus gobio* Linnaeus, 1758, *Romanogobio uranoscopus* (Agassiz, 1828), *Romanogobio kesslerii* (Dybowski, 1862), *Squalius cephalus* (Linnaeus, 1758), *Barbatula barbatula* (Linnaeus, 1758), *Alburnoides bibunctatus* (Bloch, 1782), *Sabanejewia romanica* (Băcescu, 1943), and *Sabanejewia balcanica* (Karaman, 1922) (Bănărescu and Vasiliu-Oromulu, 2004), reveal the importance of the specific food abundance and accessibility.

R. valsanicola is mainly a nocturnally-active fish, moving constantly from place to place. Analysis of the *R. valsanicola* stomach contents shows that it feeds almost exclusively on aquatic insect larvae. The dominant rheophilic and oxyphilic insect group in the *R. valsanicola* diet is by far the mayflies, among them 78% being *Rhithrogena semicolorata* (Curtis, 1834). It is obvious that *R. valsanicola* has a strong preference for *R. semicolorata* particularly because the fish can easily find this mayfly species attached to hard surfaces in the water (Găldean et al., 1997).

Similarly with *R. valsanicola*, its main prey *R. semicolorata* usually has a microhabitat relationship with the hard substrate, being generally found on and under larger boulders. *R. valsanicolai*, with its predominantly nocturnal grazing activity, coincides perfectly with the mayfly species leaving its shelters at night to consume epibiosis on surfaces of boulders (Bauernfeind and Soldan, 2012; Curtean-Bănăduc et al., 2012). In its larval stages, *R. semicolorata* also leave their shelters at night to move around and feed on the surface of stones. Generally, these stone surfaces are covered with epibiose or a periphytal layer. This layer has a very active algal life, mainly diatoms, and is a primary food source for the mayfly larvae. When the mayfly larvae leave their shelters (crevices, stones underfaces, etc.) the larvae emerge in the primary area of *R. valsanicola* activity (Găldean et al., 1997; *, 1999-2003).

Habitat is a fundamental cornerstone of fish and represent the physical and chemical features of the aquatic systems that affect survival, growth, reproduction and recruitment (Bozek et al., 2011). Ichtyofauna faces large-scale and significant negative impacts due to human changes and influences in their habitats (Cordone and Kelly, 1961; Afanasyev, 2003; Curtean-Bănăduc et al., 2006, 2007, 2018, 2020a, b; Bănăduc 2008; Trichkova et al., 2009; Telcean et al., 2011; Witkowski et al., 2013; Sosai, 2015; Popa et al., 2016; Khoshnood, 2017; Kruk et al., 2017; Marić et al., 2017; Joy, 2018; Kar, 2019; Bănăduc et al., 2020; Iordache et al., 2020).

Anthropogenically-induced impacts in *R. valsanicola*-specific habitats in recent decades have a direct influence on this fish species, as well as an indirect influence on the fish through its dominant food source, *R. semicolorata*, and other ephemeran species.

The main objectives of this study are to identify the currently modified/unsuitable types of habitats of the two species of interest, *R. valsanicola* and *R. semicolorata*, and to suggest some basin-management elements that can reduce the impact of these unwanted habitat changes, especially related with sediments issue. Notably, it was proven that elevated fine sediment input from terrestrial and aquatic sources as a result of human activity create a negative impact on aquatic ecosystems (Kemp et al., 2011). Conversely, the negative anthropogenic impacts to natural stream sediments can be reversed, too, mitigating the negative effects on invertebrates and fish communities (Ramezani et al., 2014).

Based on these objectives, it is possible over the long-term to increase individual fish numbers back to relatively similar levels in the decade from 1956-1965 along the 40-50 km stretch of water (before Cheile Vâlsanului/Vâlsanului Gorges and Vâlsăneşti locality) before the construction of the Vâlsan River dam.

MATERIAL AND METHODS

During July through September 2019, daily trips were made along the banks of the Vâlsan River three kilometers upstream and dowmstream from the Brădet locality. Fishermen were asked about what fish they had caught and any incidence of *R. valsanicola* was recorded.

During this period in 2019, 11 individual *R. valsanicola* fish caught by fishermen were identified and released in situ immediately. The fish were marked with a very small spot of paint for easy identification to avoid double counting in the analysis. The paint is biodegradable and dissapears in six months. It was noted that not all the fishermen could recognize this species or were aware of the high international conservation value of this fish.

As part of the analysis the habitat types where *R. valsanicola* were identified and noted, along with the species of other fish caught and identified in the survey.

RESULTS AND DISCUSSION

This paper draws attention to negative anthropogenic effects on the environment in addition to those known so far: the extraction of boulders from the riverbed for construction, poaching, pollution, and changing the dynamics of liquid flows due to the non-ecological management of the Vâlsan Dam (Stănescu, 1971; Bănărescu and Vasiliu-Oromulu, 2004; Bănărescu, 2005). Additional consideration is being given to the change of the solid flows dynamics. Harmful gusts of wind and clear-cutting of timber now occur in the Vâlsan Basin, which accentuates soil erosion and the transport of alluvial sediments downstream. There are, however, some proposed management and technical solutions to reduce these effects.

The change in the dynamics of both liquid and solid flows of the Vâlsan River as a result of the long-term aggressive human impact reveals one of the most important points of action of any management plan developed for the conservation of the species *R. valsanicola*.

In this context, the survey identified and described habitats where *R. valsanicola* were and were not caught by fishermen. The identified lotic sectors where individual *R. valsanicola* fish were caught had common characteristics of a riverbed composed of a majority of medium and large boulders and less sediment. In sectors where these boulders were missing or were very few, or if the river bed was covered by sediment, no *R. valsanicola* fish were found.

Despite that the geomorphological effects of peneplation are well known across the scientific community (Goudie, 2004) some ecological effects of this phenomenon are ignored or underestimated. Denudation with its components of weathering, organism activity, erosion, transport, and accumulation are continuous natural processes (Müller, 1968; Posea et al., 1976; Poons, 2008), whose indirect influence on fish is little-addressed in research.

The erosion of rocks and soil is a process of moving mineral and organic elements through a complex-but-natural process that has occurred for eons of time. The eroded material can cause both on-site and off-site effects (Parsons and Cooper, 2015), which can influence an ecosystem’s dynamic. Massive soil erosion, usually produced under anthropogenic influence, hinders the growth of plants, agricultural yields, water quality, catchment health and recreation (Pimentel and Burgess, 2013; Najib et al., 2020).

This study holds the premise that the erosion of rock and soil surfaces influenced by slope relief, climate, water, wind, gravity, hydrographic networks, vegetation characteristics, actions of organisms, types and degrees of anthropization, and more, are factors that must be analyzed and taken into account in the complex context of the need to protect *R. valsanicola*, its habitat, and its specific trophic base.

Fine sediments drifting in the flow of water exist throughout the watershed in the study area. These floating sediments are held in suspension in the water column as long as water flows have the necessary volume and speed to keep sediments from dropping to the riverbed. With low flows, reduced volume, and minimal velocity the sediment will accumulate. The transport and accumulation of silt, sand and even gravel causes problems by changing the rocky hard substratum of river beds to a more soft, sandy or muddy substratum.

It is critical understand that while the erosion of the basin, river banks, and river bed in the study was in a natural dynamic, this process of transport and accumulation was in balance. The lotic system was in a natural dynamic, helping it to qualitatively and quantitatively preserve its processes by offering natural services to the local biota and the riverine human communities. When human activities in the watershed started to have effects over a certain level of impact, it was reasonable to see the lotic system reaction, including changes in its biotope and biocoenosis structural elements.

The increase in the accumulation of sediments in some river sectors is a signal of a decreasing water-flow volume and speed in the river. The reduced capacity of the Vâlsan River to transport even normal/natural quantities of sediments coming into the basin, on top of sediments produced by human activities in the basin (removing the sand of the dam reservoir and the sills, clear cutting forests without immediate afforestations, non-compliant skid roads, erodible dirt roads, banks modification, riparian vegetation destruction, and even using bulldozers to "clean" the riverbed, etc.) along with natural events, like destructive gusts of wind, caused the increasing quantity of sediments in the river basin.

Although the survival of this fish species in such a small area is a kind of "natural miracle," the desperate need for a more applicable, carefully-executed and sustainable conservation measure needs to be widely known and acknowledged if we want to avoid the extinction of this species. In this unfortunate context, the appearance of windfalls and possibly negligent logging activities, can be something unbearable for this threatened fish species.

The biological and ecological needs of the most endangered fish species of Europe, *R. valsanicola*, and of its main trophic base, the species *R. semicolorata,* requires a strict sediment management regime, especially of the fine sediments. These fine sediments usually do not come from riverbed erosion but rather from upstream sub-basins, resulting in the most negative effects on macro and micro habitats used as shelters as fine sediments are transported in the water to both temporary and final deposits along the river.

It is worth noting that among the human activities that have a direct negative impact on soil erosion and indirectly on aquatic communities of lotic systems, unsustainable forest exploitation is right at the top, in company with land cultivation and overgrazing. In the upper Vâlsan River basin only unsustainable forestry and overgrazing are significantly present.

It should also be noted that in recent decades the sediment transport capacity of the local hydrographic network has been constantly exceeded due to the impact of human activities on one hand and climate changes on the other. The effects are visible (overcolmatation) on the minor riverbed and the associated biota.

In this general and specific conservation context, the present work proposes a set of management and technical measures, to enhance efforts to protect the *R. valsanicola* species natural sanctuary.

Sediment management general measures proposal recommendations

Reservoir-related recommendations for basin sediments management

The silting phenomenon in storage lakes/reservoirs, which are sediment sinks, is a natural, global, physical phenomenon which cannot be avoided. Also, the normal evolution of oligotrophic to mesotrophic and finally the eutrophic state of these lakes due to sediment accumulation leads to habitat changes and influences the downstream effluent lotic system physico-chemical and trophic status.

These effects may be retarded, however, in the following ways:

– extraction/clearing of the Vâlsan River storage lake/reservoir and transportation of the fine sediments (sand and mud) to specifically identified and designated storage sites far downstream, along with a ban on washing sediment deposits by discharging them downstream into the river, this being to stop spillage of all sediments and sludge by periodic clearing of the lake bottom;

– between dredging the lake bottom, mitigating downstream sedimentation effects by periodically covering the lake-bottom sediment with plastic or rubber sheeting materials;

– equipping the front barrier of the concrete dam (the upper part of the barrier of the concrete dam) with specially-designed and constructed mobile elements (an inflatable rubber dam or a gated dam without bottom sills under one meter high) so that, during large flows – where the alluviums' transport is so prevalent – the lake's outflows of sediment will match near-natural levels;
– another solution, which is a variation on the previously proposed solution, is diminishing silting by using weirs, with adequate adapted dimensions, so that in flood conditions escaping sediments will be kept to natural levels;
– an alternate solution, which might offer remarkable results, is that of creating some outside-of-river-bed storage lake, in which the flowing water will always be channeled except during the flood periods. This solution may be achieved with: a permanent or mobile diversion dam, a headrace, and a storage lake, with the main course of the river keeping its own route and the remainder of the water flow and discharge transported away during flood periods;
– all the existing torrents's fitting-out and soil erosion control works, in the lake basin should be achieved (Tecuci, 1993).

Forestry-related recommendations for sediment basin management

Numerous forestry management measures are already part of the Romanian legislation (Ministry Order 1540/2011) (Stăncioiu et al., 2008; Bucur, in verbis) and if they are adhered to in the field they can be effective conservation management measures.
– the forest stands' vertical and horizontal structure should be as close as possible to its natural model (multi-layers, groups, and patches) in order to reduce soils being destabilized because of slope characteristics, loss of moisture, loss of large canopy cover, loss of root strength, etc. The preferred management regime should be irregular shelterwood or a selection system;
– permanent watercourses will be protected by commercial intervention with a minimum 50-meter-wide stripe on both sides of the watercourse. Inside these stripes, minimal conservation fellings can be allowed if they are strictly needed. The cross-over, in accidental or extraordinary cases when it cannot be avoided, will be made over the shortest distance on installations adopted to keep the water clean and soil erosion at minimum;
– riparian forest and the natural bushy and grassy, local vegetation and flora will be strictly protected;
– any timber harvesting or transport activity is recommended to take place on a frozen substrate, covered by snow and/or ice and on well-maintained forestry roads with a layer of mineral aggregates on top of the road;
– the network of forestry roads must be optimally dimensioned – maximum efficiency with the minimum amount of damage;
– existing roads should be preserved and maintained in order to avoid or minimize erosion, sediment transport and accumulation in the area;
– building of new forestry roads should be avoided;
– ecologically friendly, low-impact logging technologies (oxen, horses, cableway-skidders) are always preferred;
– timber will not be removed from forests during or after precipitation while the soil is moist;
– skid-roads will always be designed, built and monitored in order to avoid soil-erosion as much as possible, ensure the protection of permanent and temporary watercourses, and protect remaining trees;
– sensitive areas like potential land-slide zones, talus, cliffs, steep slopes, etc., will be identified, protected (excepted from logging), and monitored;

– it will be prohibited to store timber (even for short periods of time) in the riverbed, on its banks, and on the minimum 50-meter-wide protection stripes adjacent to both perennial and ephemeral waterways. All the vegetation within the protection belts shall remain intact;
– intervention cuttings will be applied in openings with a diameter up to a tree height, from which the old trees can be completely removed;
– timber harvesting will not exceed 10% of the volume of the stand (exceptions can be allowed in special accidental situations, for example windfalls and/or snowfalls, etc.), and the harvest volume will be correlated with the condition of the stand, the dynamics of natural regeneration, and with assigned conservation requirements;
– logging techniques will be adopted to minimize the level of injuries to the remaining trees and soil;
– if there are stands in which the natural regeneration is very difficult or stands are affected by calamities, replanting or direct sowings will be carried out using only seminological material of local origin or, if not possible, from identical ecotypes;
– timber harvesting access corridors should run parallel to the lotic and lentic ecosystems;
– pioneer species will not be extracted as they are important for soil improvement;
– illegal logging will be controlled with the aim to eradicate illegitimate logging activities;
– during logging and timber transport activities, sediment traps will be installed on the main watercourses (with around 500 m distance between them), and will be cleaned as often as necessary, with their evacuation/transport in areas that do not influence the degree of sedimentation in waterways;
– construction/monitoring/maintenance of drainage ditches for liquid and sediment flows from the transport routes designed to manage excessive and rapid precipitation events that are characteristic of the mountain area;
– installation of sediment traps (with around 500 m distance between them) on ditches used to evacuate liquids from the transport routes, cleaned as often as necessary, with the anticipation that the proposed sediment traps will stop, or at least diminish, the potential of these channels networks to be an unwanted sediment delivery system directly to downstream water bodies;
– leafy branches and debris left over from the logging will be placed on remaining stumps;
– full reforestation of the watershed with canopy projection over 0.8 (to reduce the kinetic energy of raindrops on the soil surface, surface runoff from precipitation, air currents, solar radiation, and minimize large temperature differences, etc.) and subsequent forest management regime;
– excluding human activity in the riverbed of watercourses and preserving permanent or temporary riparian wetlands as natural sediment traps during periods of increased precipitations and high flows;
– the construction of new bridges, if needed, should not narrow the waterway to avoid increasing water speed and its capacity for erosion and sediment transport to downstream sectors;
– ecological restoration of sediment deposits formed at high waters in the riparian areas by fixing sediments or planting on sedimentary areas will prevent sediments from moving downstream in subsequent episodes of high flows;
– efforts should be made to favor existing flora, undergrowth, shrubs, and the herbaceous bed;
– it is acceptable to intervene with sowing or planting in critical areas;
– leaving the stumps in situ;
– controlling waste management;
– closing the basin to any other hydrotechnical works of any type that do not align with an optimum basin sediment management.

The proposed management regime needs to be officially recognized, and social, environmental, and economic objectives need to be assigned to the forest in the watershed (e.g. the dam on Vâlsan River, an ecological preservation area established for the protection of this endangered species, etc.). For immediate action, however, measures such as a credible forest management certification scheme (like FSC®) could be an efficient solution.

Basin sediments general management recommendations

Sediment control in the basin is specifically important for water quality in the basin, but indirectly sediments cause other problems. Sediments are not pure can be attached to or carry additional contaminants. To avoid such situations different measures can be implemented:

– monitoring slopes, torrents, banks, etc., particularly those prone to accidental or permanent erosion;
– in areas with significant accidental erosion, the effects of erosion can be decreased with blankets, rugs, geotextile materials, sandbags, gravel bags, plastic materials dams, etc., until the situation is stabilized through ecological reconstruction;
– creation of thick, vegetated fencerows, due to their role as traps for sediments and nutrients;
– prohibit the extraction of mineral resources in the basin and instead offer access to other sources of materials for construction to local populations;
– prohibit damming or regulating riverbeds with hydrotechnical works, with the exception of debris basins, settling ponds, and other similar structures which can catch sediments, which can then be regularly cleaned up;
– suspend tourist paths through areas where the vegetal layer needs to be preserved or improved;
– roads should not interfere with the buffer stripes, off-road vehicles will be banned;
– prohibition on burning vegetation and trimmings;
– fire will be allowed only in specially arranged areas located outside forests;
– any burning of vegetation and trimmings will be done only with the approval of the competent authorities and with the prior notification to the public services for emergency situations;
– banning grazing and watering domestic animals in the forest and, as much as possible, in other areas that drain in the basin to mitigate the impacts of soil compaction, decrease water infiltration in the soil, increased runoff, and erosion;
– use specially-selected (rocky) areas in wider and shallow channels for cattle, goats and sheep to use for drinking to avoid trampling down the vegetation, river bank erosion, water turbidity, sediment accumulation downstream, and consequently increasing riverbed erosion, etc.;
– domestic animals will be prohibited until grasses are restored to a normal level;
– in pastoral lands, grazing will be regulated to avoid the destruction of flora, soil compaction and the onset of erosion phenomena and will even be prohibited in sensitive periods or areas;
– the transhumance activities of animals including passing through, grazing and overgrazing, watering, etc., should be avoided or at a minimum guided and monitored to avoid erosional impact;
– the disposal and storage of sawdust and other waste is strictly prohibited;
– dragging wood around riverbeds and storing wood in and arround riverbanks is prohibited;
– a ban on unorganized tourism;
– a ban on the replacing forests and pastures with intensively-used agricultural lands;
– small farms are preferable to large, industrial farms;

– the runoff from mines and mines deposits should be isolated from the water network;
– natural water filtration areas and detention ponds should be promoted and used in localities and by contrast hard surfaces, which increase runoff and the transportation of sediments should be minimized, especially hard surfaces associated with the construction of buildings and roads;
– monitoring the ecological status of what are considered sediment-sensitive fish (*R. valsanicola*) and macroinvertebrate (mayflies, especially *R. semicolorata*) and use the results as an indication of qualitative and quantitative sediment changes;
– the realization of a basin conservation management plan, which includes sediments management, for the Vâlsan Basin, for *R. valsanicola* conservation in a first phase, and later for the Argeş Basin, with the same main objective of extending the areal of this fish species.

Riverbed ecological reconstruction approach proposal

Understanding the effects of hydro-morphological pressures created by the presence of transversal works on rivers is of great importance (Kay and Voicu, 2013; Voicu et al., 2020).

Due to the transversal constructions made on the Vâlsan River, especially the dam from Brădetu, the flow downstream from this dam does not offer the volume and speed of water flow necessary for the optimal functioning of the studied lotic system in its natural regime, and consequently an insufficient flow for an optimum habitat of *R. valsanicola*.

Both the clogging and the drastic decreasing in number, and in some sectors the total lack of boulders has led to the habitat of *R. valsanicola* and its main trophic base destruction.

A pilot ecological reconstruction project is recommended on a one-kilometer-long stretch of the Vâlsan River. Based on performance results after a few years of monitoring if this action is enough to successfully attract and sustain a permanent *R. valsanicola* community, then this type of ecologic reconstruction can be extended along the river.

A semi-circular transversal section of riverbed must be built in the existing riverbed of the Vâlsan River, on which 90% of the downstream flow, at low flows resulting from the Brădetu accumulation, must be redirected, as a refugee habitat for the fish (Fig. 1).

The riverbed must be made of cement and expanded clay, and boulders need to be abundant in the upstream sector of the river (Fig. 1).

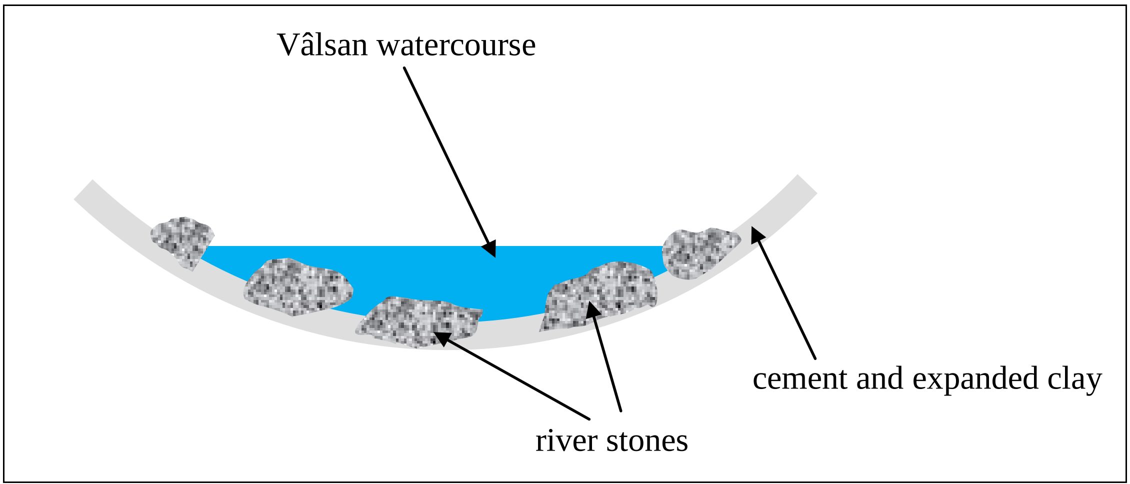

Figure 1: The new reconstructed riverbed with fixed boulders in a mixture of cement and expanded clay at the base (transversal section).

The reconstructed riverbed in the Vâlsan River is made of medium and big boulders (those with a green edge – Fig. 2) with approximately one meter spacing between them and random positioning, mimicking the natural riverbed sector found upstream. Some larger stones measuring meters across will be placed in the riverbed as well.

The mixture of cement and expanded clay will fix the boulders in the substrata and then these stones cannot be taken by the local residents for construction projects. The placement of the stones and boulders will be such to preserve the connectivity between the river and its hyporheic zone.

The new riverbed is well fixed to the old riverbed (and in the soil) and thus in case of flood the new riverbed will remain in place without significant damage. Minor damage can be easily repaired. In case of drought, the river water will flow only in the new riverbed, which will ensure an optimal flow for *R. valsanicola*. The water flowing through the existing riverbed will revive the insect species that feed this species of fish. If the project is respected and if quality materials are used, the new riverbed will have easy maintenance for years to come.

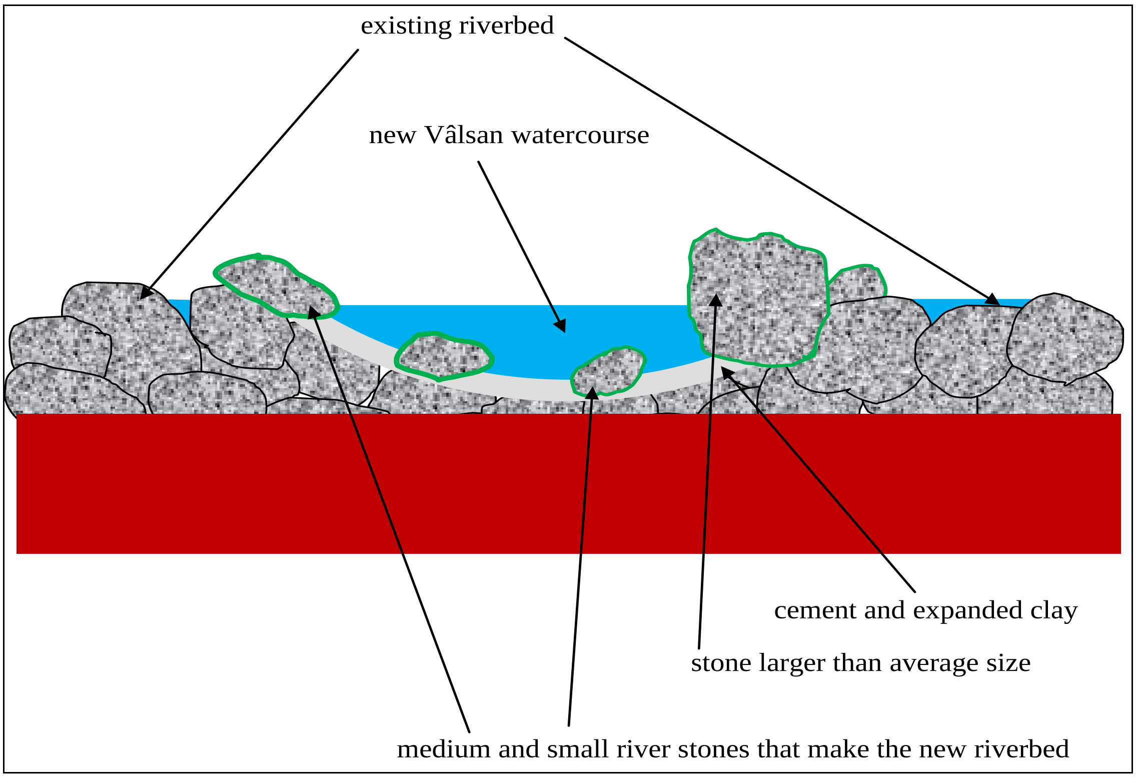

Figure 2: Positioning of boulders and stones in the reconstructed riverbed.

The minimum water flow of the Vâlsan River downstream of the Brădet Dam, due to droughts and/or bad flow management, will be redirected to the new riverbed with the help of river boulders and stones fixed to new riverbed with cement and expanded clay (Fig. 3).

These rows of stones will not reach the banks of the river, leaving space for water to enter the existing riverbed, and also room for fish to expand their lateral distribution in periods with high water levels. The flow left on the laterals of the reconstructed riverbed is of 10% of the flow when water flows are low.

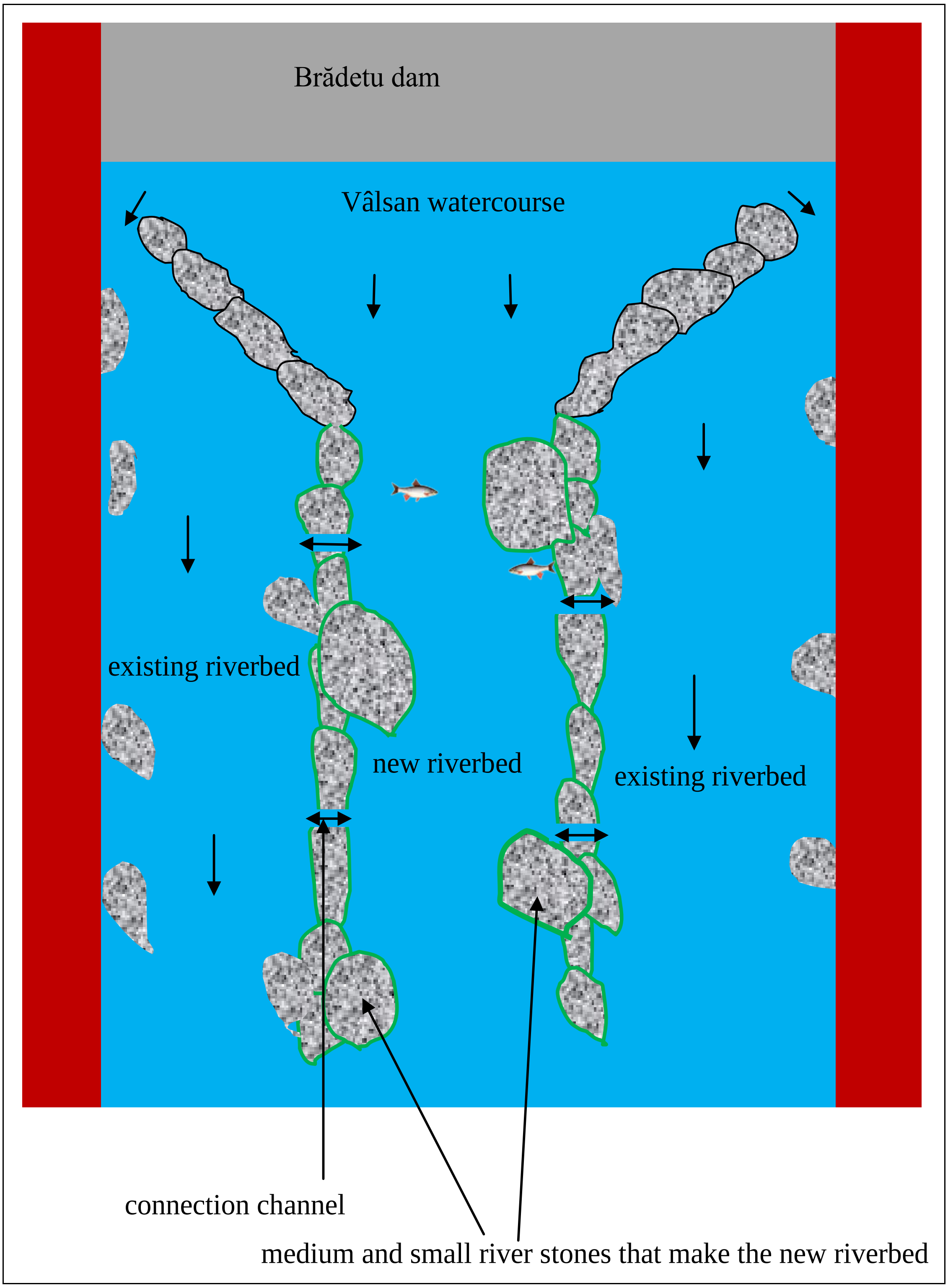

Figure 3: Upper view of the old and newly-reconstructed core riverbed.

The reconstructed central riverbed sector should to be around one third the width of the total, actual riverbed, with one third width on the left and one third on the right of the old riverbed. Every five meters there are some 15-to-20-centimeter-wide channels that connect the old and the new riverbed (Fig. 3). Through these channels the invertebrates and fish can pass between the river bed center to lateral sectors and back at high flows, and can find shelter during low flows in the newly reconstructed center riverbed sector.

The new reconstructed riverbed center sector will have a constant flow corresponding to its size. This is needed to ensure adequate flow intensity to carry away sediment and not permit clogging or sediment covering on the boulders in case of high sediment discharges.

The sediments will be kept suspended and carry on downstream in the new water flow conditions with a sufficient water volume to keep sediments from dropping to the riverbed, even at lower water flows.

Finally, a monitoring system should include surveillance of the Vâlsan River dam water flow management, which should release a continuous and sufficient water supply for the river. In the end, the main monitoring indicator of the Vâlsan Basin will remain the ecological status of *R. valsanicola*.

CONCLUSIONS

Past research in the area of *R. valsanicola*-specific habitat has not focused on stream sediments. Poor water and land use imposed significant long-term effects on natural lotic systems, namely of a change in the physical structure and cover on fish habitat and the fish themselves. This is especially due to the human-induced, excessive increase in fine sediment in the hard riverbed habitat of *R. valsanicola*, which had a significantly adverse effect on this most endangered fish species of Europe.

Due to the need for greater understanding from authorities for a larger, permanent water volume to be released downstream from the Vâlsan Dam, or for the necessity of investments in reshaping/adapting the Vâlsan Dam to protect the most endangered endemic fish species *R. valsanicola*, fast, less-expensive solutions were offered here. To support the key decision makers, adaptative management and technical ecological elements were identified and proposed (dam reservoir-related recommendations for basin sediments management, forestry related recommendations for sediment basin management, basin sediments general management recommendations, riverbed ecological reconstruction approach proposal, etc.) to be implemented in the local basin management plan to decrease the fine sediments accumulation by stopping the excessive sediments running down from the basin, facilitate their transport downstream away from this impact area, and finally, improve the *R. valsanicola* species ecological status.

The habitat managers are required to specifically monitor the extent to which the changes in physical structures and cover for *R. valsanicola* habitat will affect this fish and its trophic base in the future.

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RIPARIAN VEGETATION ALONG THE SCROAFA STREAM AND ITS TRIBUTARIES (SOUTHERN TRANSYLVANIAN TABLELAND) UNDER CHANGING ECOLOGICAL CONDITIONS AND HUMAN INTERVENTION

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KEYWORDS: riparian forest galleries, willow softwood stands, habitat type 91E0, stream bed structure, tributary of Târnava Mare River, Danube Basin.

ABSTRACT

The riparian softwood galleries of the Scroafa Stream basin, part of the South Eastern Transylvanian Tableland are presented and discussed under the aspect of their site conditions, species composition, vertical structure by different layers, ecological requirements and their change along the stream banks from the source to the mouth in the Târnava Mare River. Their stretches are compared, with commonalities and differences highlighted. The impact of human dependent changes and the future of the galleries with climate changes are addressed. The importance of the riparian softwood stands is also presented in the context of the Natura 2000 network, as they are included in the list as priority habitat types.

ZUSAMMENFASSUNG: Die Ufervegetation entlang des Saubachs (Pârâul Scroafa) und seiner Zuflüsse im Hochland Süd-Siebenbürgens unter veränderten ökologischen Bedingungen und menschlichen Einflüssen.

Die Galerie-artigen Weichholzauenwälder aus dem Südwesten des Siebenbürgischen Hochlands werden vorgestellt und unter dem Aspekt der Standortverhältnisse, der floristischen Zusammensetzung, der Vertikalstruktur, der ökologischen Ansprüche sowie ihrer Veränderung in der Abfolge von der Quelle bis zur Mündung in die Große Kokel und besprochen. Die Veränderungen durch menschlichen Einfluss sowie auch die Zukunft dieser Auwälder unter den Bedingungen des Klimawandels werden angesprochen. Die Bedeutung dieser Weidenuferwälder wird auch im Kontext des EU Natura 2000 Netzwerks dargestellt, da sie unter den prioritären Lebenräumen gelistet sind.

REZUMAT: Vegetația ripariană de-a lungul Pârâului Scroafa și a afluenților săi (Podișul Transilvaniei de Sud) în condiții ecologice schimbate și a impactului uman.

Zăvoaiele de sălcii ale pârâului Scroafa din partea sud-estică a Podișului Transilvaniei sunt prezentate și discutate sub aspectul condițiilor staționale, a compoziției floristice, a structurii verticale, a cerințelor ecologice și a schimbării lor pe sectoare, din amonte în aval, de la izvoare până la vărsarea în râul Târnava Mare. Sunt evidențiate schimbările cauzate de impactul uman, precum și prefigurat viitorul zăvoaielor în condițiile schimbărilor climatice. Importanța zăvoaielor este prezentată și în contextul rețelei Natura 2000, zăvoaiele fiind listate ca habitate prioritare.

INTRODUCTION

One of the best examples of surviving traditional European landscapes where the local and regional cultural diversity and traditional management are still alive, allowing the presence of exquisite habitats and species, is the Saxon Villages area in southern Transylvania, Romania (Hartel and Demeter, 2005; Mountford and Akeroyd, 2005; Akeroyd, 2007; Benedek, 2007; Cowell, 2007; Curtean-Bănăduc and Bănăduc, 2007; Curtean-Bănăduc et al., 2007; Drăgulescu, 2007; Gheoca, 2007; Ghira, 2007; Hartel et al., 2007; Jones, 2007; Oroian et al., 2007; Schneider-Binder, 2007). The human impact in the context of climate changes, jeopardize these areas, new assessment and monitoring studies are needed for their protection.

The Southern Transylvanian Tableland is characterized by a large network of streams with different discharge, tributaries to the larger rivers crossing the tableland. Representative of the south-southeastern part of the Transylvanian Tableland is the Scroafa Stream (Saubach), its river basin being situated in the contact area of the Southern Transylvanian Tableland and the Sub-Carpathian hills (Badea et al., 1976; *, 2010; **, Raduly, 2014; **, 2015). The Scroafa Stream is a left tributary of the Târnava Mare River with a length of 39 km and a river basin with an area of 334 km² (*, 2010). Its springs are situated upstream of the village Roadeş (Radeln) on the foot area of Dealul Chiliei/Chiliei Hill, in the place named „La Gloduri" which means boggy area with seeping water. The water collected by a small stream flows in an eastern direction, crossing to the south on the border of the village. Near the road from Brașov to Sighișoara, it curves in a western direction crossing the community of Bunești (Bodendorf) and continues in a northeastern direction. Flowing tangential to the villages Criţ (Deutsch-Kreuz) and Mihai Viteazu (Zultendorf) the stream reaches the community of Saschiz (Keisd).

On this stretch from the springs to Saschiz, the Scroafa Stream collects the water from many small tributaries of the second and third range which are on the right side of the stream: "Pârâul de la Lunca Popii" near Buneşti, the streamlet "Pârâul lui Müller" between Criţ and Mihai Viteazu at the foot of the Coasta Morii Hill, the streamlet "Fundătura" at Mihai Viteazu, the "Pârâul Pietros" between Mihai Viteazu and Saschiz, and many smaller ditches with scarcely flowing water, except during rainy periods. From the left side flows in at Bunești the streamlet of "Valea Lacului" and on the border of the village Criţ the stream "Pârâul Meşendorf" coming from the village Meşendorf (Meschendorf). Also at Criţ flows in the streamlet "Daia" with the small ditch of "Valea Zaifan (Seifen)". The streamlet "Pârâul Cloaşterf (Klosdorf)" crosses the village of the same name, flows into the Scroafa Stream downstream from the village Mihai Viteazu. From the community of Saschiz the Scroafa Stream turns to the north, collecting on its right side the stream "Pârâul Archita" of the village Archita (Arkeden) into which flowed next to Mureni the streamlet "Pârâul Feleac" crossing the village Feleac (Flagen), and many other smaller streamlets. From the mouth of Archita Stream into the Scroafa Stream at the foot of the hill "Dealul Făgeţelului" the Scroafa Stream flows in north-northeastern direction in the floodplain between the Bandi Hill on its right side and the Dealul Rotund Hill on the left into Târnava Mare River at the large floodplain "Şesul Mare" east of the community of Vânători (altitude 377 m).

On the Pârâul Scroafa and its tributaries are apparent the valleys with V or U forms with one or two levels (small terraces) deepened on some stretches considerably by the former hydro-morphodynamics of the stream through the layers of tertiary argile, marl, and sandstone.

Pârâul Scroafa has a changing discharge with high levels in spring time and low or very low levels during summer and autumn. During summertime, high water can frequently develop due to heavy rainfalls, with levels and discharges having torrential character associated with erosion and deposition processes (Tabs. 1 and 2). The maximum annual discharge is 3.17 m³/s and the minimum 0.20 m³/s (Raduly, 2014).

Table 1: Periods of registration at gauge Saschiz (according to Raduly, 2014, with small additional data) and the gauge Vânători on the river Târnava Mare downstream from the mouth of Scroafa Stream (for comparison).

River	Gauge	Basin surface	Mean altitude	Establishment of gauge	Period of direct data	Average flow m^3/s
Scroafa Stream	Saschiz	190 km^2	570 m	1982	1982-2012	0.577
Târnava Mare River	Vânători	1,771 km^2	680 m; at mouth of Scroafa Stream 377 m	1970	1970-2012	9.225

Table 2: Basic data concerning the mean multiannual discharge of Scroafa Stream and Târnava Mare River (according to Raduly, 2014, with small additional data).

River	Gauge	Surface basin	Mean altitude	Average flow m^3/s	Flow $l/s\ km^2$	Flow volume mil. m^3	Flow height (mm)
Scroafa Stream	Saschiz	190 km^2	570 m	0.562	2.957	17.72	93
Târnava Mare River	Vânători	1,771 km^2	680 m, at mouth of Scroafa 377 m	9.613	5.428	303.15	171

The grain size of sediments vary widely; changing from stretch to stretch dependent on the geological layers crossed by the stream, and are frequently visible on the slopes of the deepened river bed. Many of the small tributary streamlets dry out in summer time, remaining only as a small stream channel or entirely disconnected water pools in places where the stream valley is deeper. Depending on the structure and thickness of tertiary layers of argil, marl, and sandstone as well as their different erosion – with the result of various grain size of sediments – the transported and deposited materials build on the stream stretches differently structured river beds and river banks. Frequently the water formed over long periods of time locally deep canyon-like valleys with steep slopes.

The Scroafa Stream has a larger bed with a characteristic morphology, steeper slopes on some stretches and a higher discharge same as its tributaries. Only the stream of Archita has on some stretches a similar structured river bed as the Scroafa Stream with slopes and channel flow. The structure of the stream bed, the hydrological and morphological dynamics are determining factors for the structure of aquatic and riparian habitats and their vegetation.

The whole network of streams and streamlets of the Scroafa River basin is accompanied by galleries with softwood stands, edified mostly by two dominant willow species the white willow (*Salix alba*) and brittle willow (*Salix fragilis*), other willow species too and locally poplar species such as white poplar (*Populus alba*), grey poplar (*Populus canescens*) and black poplar (*Populus nigra*). On some higher sites, a transition area, species of hardwood forest occurs like oak (*Quercus robur*), field maple (*Acer campestre*), and others. Over the course of decades, many changes happened due to human intervention in the area. These galleries as well as forests entered into decline. Reduction of surface extent and changes in site conditions led to loss of habitats, their structure, and biodiversity. To protect these galleries and to restore them as much as possible they have been included in the priority habitat types. These floodplain softwood galleries were included in the priority habitat type * 91E0 of the Natura 2000 network of the European Union (Interpretation Manual EUR 28, 2013).

MATERIAL AND METHODS

During the vegetation periods of the years 2013-2018 field research concerning the riparian priority habitat type 91 E0* alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*, in particular the subtype arborescent galleries of *Salix alba*, *S. fragilis* and *Populus nigra*, along medio-European lowland, hill or sub-montane rivers (44.13: Salcion albae), was conducted on the Scroafa Stream and its tributaries, part of the Natura 2000 site Sighișoara-Târnava Mare of the Southern Transylvanian Tableland (Gafta and Mountford, 2008; EUR28, 2013). Samples were taken along chosen stretches according to the method of Braun-Blanquet with the seven-degree abundance-dominance scale (Braun-Blanquet, 1964; Borza and Boşcaiu, 1965). From upstream to downstream the following stretches are considered: 1. The upper part of the stream from Roadeș to Bunești, from the spring, to the small stream with some dynamic sites on the right side of the road Brașov – Sighișoara and the stretch on the left side including the stream stretch with a small island and gravel banks; 2. Bunești – Criț; 3. Criț – Mihai Viteazu; 4. Mihai Viteazu – Cloașterf – Saschiz; 5. Saschiz – Mureni (including Archita and Feleac); and 6. Mureni – Târnava Mare. The study also included the tributaries from the right side such are on stretch 1 “Pârâul de la Lunca Popii” near Bunești and from the left side at Buneşti the streamlet of “Valea Lacului”. On stretch 2 Bunești – Criț, the main tributaries flows in from the left side. These are “Pârâul Meşendorf” and “Pârâul Criț/Daia” with the ditch of Zaifan (Seifen). On the following stretch 3, a shorter one, Criț – Mihai – Viteazu, the main tributary is the “Valea/Pârâul lui Müller” near the hill of Coasta Morii. The stretch 4 Mihai Viteazu – Cloașterf – Saschiz, includes a large network of small valleys and ditches partly with low discharge or most time of the year with no water, but with a high discharge during heavy rainfalls. The main tributary on this stretch is the streamlet of Cloașterf on the left side and on the right side “Pârâul Pietros”, the “stony stream”. On stretch 5, the main tributaries from the right side are Archita with “Pârâul Feleac”. The last stretch 6 is from the floodplain downstream of the confluence of Scroafa and Archita streams to Târnava River.

The samples are included in phyto-coenological tables and grouped according to the stretches to their structure units, i.e. layers: trees, shrubs, regenerations of wood vegetation, lianas, tall herbaceous, herbaceous layers with characteristic species of the phytocoenological units and presented as well in the context of the European Union habitats (Gafta and Mountford, 2008; EUR28, 2013). The indicator values for wetness (W/F) and nitrogen (N) are included as well in the table according to Ellenberg et al. (2002) and Sârbu et al. (2013). The nomenclature of species is given according to Oberdorfer (2002), Ciocârlan (2009), and Sârbu et al. (2013).

As the data is considerably large with 49 samples for the riparian forest vegetation and 274 species altogether, we generated a synthetic table (in five columns) with easily interpretable results. For this reason, the samples from the studied stretches are represented according to the frequency values in percent (Oberdorfer, 1992a, b; Coldea et al., 2015). In this way, the characteristic and relevant species of the riparian vegetation can be clearly identified as Salicetum albae-fragilis Issler 1926 em. Soó 1957 (Drăgulescu, 2007) and also the species which indicate the influence of human activity.

The samples were used for species composition and structure of the phytocoenoses and their ecological requirements study, for the analysis of the state, succession and regeneration of riparian galleries. All the phytocoenoses were considered in strong relation with the hydro-morphological dynamics, the grain size of sediments and the succession of the vegetation along ecological gradients from the river banks to the higher elevations of the river valleys.

For studies of changes in the riparian landscape due to the changed flow regime, the water volume and structure of the river bed as well as changes by human activities, old data and photographs, as well as interviews with the local people were used.

RESULTS AND DISCUSSION

Studying the river bed structure in strong relation with the riparian vegetation, it becomes very clear, that in prior times along the decades and centuries, the discharge of the Scroafa Stream has been higher than at present time. The higher discharge can be stated comparing old pictures and photographs which shows in the twenties of the last century (1927) the use of the Scroafa Stream on the weir at Saschiz for swimming and bathing (Fig. 1).

Figure 1: Bathing and paddling on the Scroafa Stream at Saschiz in 1927, family archive photo.

This weir still exists, but is abandoned due to the low discharge related to climate changes, associated with low rainfalls increasing dryness in summertime and water pollution. The higher discharge of the Scroafa Stream in former times can also be concluded by the actual structure of the river bed (Fig. 2) and as well by the old name “Fischergasse” (street of fishermen) in the community of Saschiz on the left riverside, name given in times that permitted fishing on a larger scale in the Scroafa River with higher water levels and significant higher discharge. As a result, aquatic organisms including fish diversity is low too in such rivers (Curtean-Bănăduc and Bănăduc, 2007)

As mentioned, the stream can be divided in sections, according to the slope, the water dynamic, the morphological structure of the river banks and the river bed, the different grain size of sediments, and changing vegetation in function of site conditions and human intervention. These are given by the communities, the occupation of the inhabitants and the use of the surrounding area influencing the watercourse.

Downstream from Roadeş, on the border of the village, small galleries of white and brittle willows (*Salix alba* and *S. fragilis*) can be observed, with deeper valley segments, but also with more or less flat parts. The small stream presents near to the bridge of the national road from Braşov to Sighişoara, gravel banks with coarse rounded stones which presume a high dynamic during torrential rainfalls. The consequence of this dynamic was also visible in 2013 on the stretch downstream the bridge, on the so-called "island" near to Buneşti. Such type of dynamic, enable the building of bare sites, with fine sized and nearby coarser sediments, favorable for colonization of pioneer species such as purple willow (*Salix purpurea*), lesser centaury (*Centaurium pulchellum*), and small flatsedge (*Cyperus fuscus*) (Tab. 1, col. 1). The pioneer vegetation of the finer sized sediments is represented in the area only as fragments and takes part of the habitat type 3270: rivers with muddy banks with Chenopodium rubri p. p. and Bidention p.p. vegetation (EUR28, 2013). On this upper stream stretch, the riparian vegetation is well represented by small belts with structured layers. Characteristic for this part is the high dominance of softwoods as different willow species, in particular white and brittle willow (Fig. 2). Poplar species are lacking here, but can be found in the lowest part of the Scroafa Stream near to the mouth into the Târnava Mare River (Fig. 3).

Figure 2: Riparian gallery on the Scroafa Stream with white and brittle willow and floodplain abandoned meadow with Canadian goldenrod upstream from the community of Saschiz.

Figure 3: Scroafa Stream with gravel banks and stands of white poplar (*Populus alba*) on the confluence with the Archita Stream.

The second stretch (Tab. 1, col. 2) from Bunești to Criț is characterized by the influence of the tributaries from the right and the left side of the Scroafa Stream. These are the streams "Pârâul de la Lunca Popii" and from the left side "Valea Lacului". The smaller channels and the structure of the river bed – frequently with a small terrace (Fig. 4) – allow the settling and evolution of hardwood forest species such as wild pear (*Pyrus pyraster*), field maple (*Acer campestre*), wild apple (*Malus sylvestris*), common ash (*Fraxinus excelsior*), and many shrub species between them common dogwood (*Cornua sanguinea*), blackthorn (*Prunus spinosa*), spindle bush (*Euonymus europaeus*), and others. Blackberry (*Rubus caesius*) is present with high frequency in samples taken along the main stream and the tributaries.

The third stretch (Tab. 1, col. 3) from Criț to Mihai Viteazu includes from the right side the tributary "Valea lui Müller" including the mouth area in the Scroafa River, and from the left side the Meșendorf Stream and as well the Daia Stream with Zaifan. The smaller tributaries with locally deep valleys are also representative of this stretch. Unique to the Daia area and the ditch of Zaifan is a cooler microclimate offering site conditions for the settling of stands with mountainous character, typical for the beech forest level. These include for example sticky clary (*Salvia glutinosa*), the tall herbaceous white butterbur (*Petasites hybridus*), and locally *Telekia speciosa*, but the grey alder (*Alnus incana*), also characteristic for tributary valleys of the Târnava Mare River, as, for example in the neighbouring Șapartoc Valley, with particular microclimate conditions (Schneider-Binder, 2019) was not encountered.

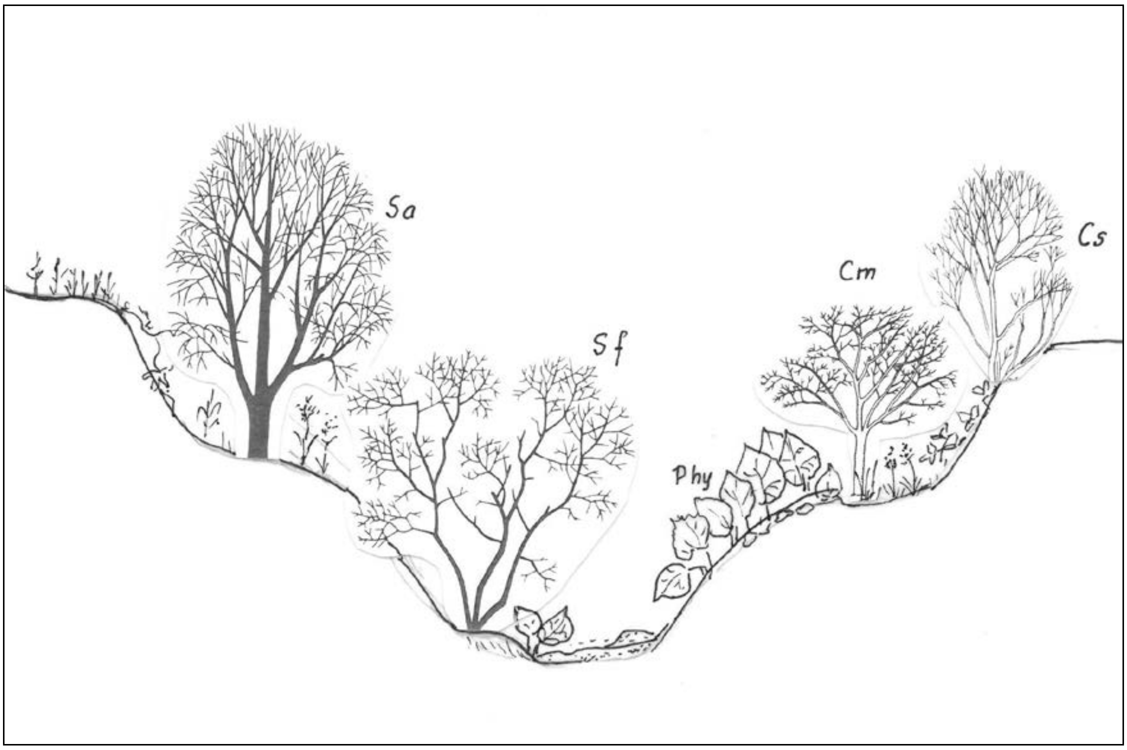

Figure 4: Distribution of the riparian vegetation on the Meșendorf Stream, on the left side of Scroafa Stream in the deep valley stretch with terrace, characteristic also for some of the other streams of the river basin; abbreviations: *Sa* = *Salix alba*, *Sf* = *Salix fragilis*, *Cm* = *Crataegus monogyna*, *Cs* = *Cornus sanguinea*, *Phy* = *Petasites hybridus*

On the stretch from Mihai Viteazu to Saschiz (Tab. 1, col. 4), the gallery forest of willows include poplar species, same as the previous stretch. The characteristic species are in general present, but the small belts are less compact around the community of Saschiz. Increasing stands of the alien ashleaf maple (*Acer negundo*), which is in expansion in the tree layer as well as the shrub layer of the forest stands. The regeneration of willows is only locally present, but in general lacking. It reappears in the stretch downstream of the community, where a higher dynamic with pioneer sites exists (Tab. 1, col. 5). The dynamic with changing gravel banks is remarkable in particular on the lower stretch of the Scroafa Stream with gravel and larger sandstone sheets and with gravel banks on the confluence of the Archita Stream as the largest tributary of the Scroafa Stream (Fig. 5).

The high number of weeds characteristics for ruderal places, waste disposal sites and other disturbed areas, including in the sorrounding areas (Akeroyd, 2007), are clear proof of human activities, in particular around the villages and communities of the Scroafa Stream basin (Tab. 3, cols. 1-5). These species take part in the phytocoenological units: class Artemisietea with the orders Glecometalia, Alliarietalia, alliances Aegopodion and Alliarion), order Artemisietalia with the alliance Arction, as well as Onopordetalia with the alliances Onopordion and Dauco-Melilotion characteristic for disturbed places. Weed species of the hack-crops area (Chenopodietea) and cereal agricultural land weeds (Secalietea) are also represented. Many of these species are indicators for nitrogen-rich sites. This can be concluded by the indicator values, mentioned in the table for the distinct nitrophilous species (value 8) and those indicating an excessive nitrogen-rich site (value 9).

Figure 5: The Scroafa Stream with riparian white willow stands and fine sized sediments, gravel, and sandstone sheets in the stream bed, downstream the community of Saschiz (2013).

Table 3: Riparian forest association Salicetum albae fragilis (synthetic view).

		Column/stream stretch	1	2	3	4	5
		Number of samples	10	5	12	10	12
		Frequency %	F	F	F	F	F
U/W	Cenol.	**Tree layer**					
8 =	Sal	*Salix alba*	90	100	100	100	100
8 =	Sal	*Salix fragilis*	90	100	100	100	100
8 =	Sal	*Populus nigra*	–	–	16.6	10	8.33
8 =	Sal	*Populus canescens*	–	–	16.6	20	16.6
7 ~	Al-U	*Populus alba*	–	–	16.6	30	25
9 =	Al-U	*Alnus glutinosa*	–	–	8.3	–	16.6
6	Al-U	*Acer negundo*	–	–	25	50	33.3
5	Fag	*Fraxinus excelsior*	40	40	8.3	–	–
5	Qu-F	*Acer campestre*	30	40	16.6	30	–
x	Qu-F	*Quercus robur*	10	–	25	10	–
5	Qu-F	*Pyrus pyraster*	10	40	8.3	10	–
6	Ti-Ac	*Acer pseudoplatanus*	20	–	–	–	–
6	Ti-Ac	*Tilia platyphyllos*	–	–	8.3	10	–
4	x	*Robinia pseudaccacia*	10	20	50	10	41.6
5	x	*Populus tremula*	–	–	16.6	10	–
6	x	*Juglans regia*	–	–	–	30	8.33
4	Prun	*Crataegus monogyna*	10	–	33.3	–	–

Table 3 (continued): Riparian forest association Salicetum albae fragilis.

U/W	Cenol.	**Shrubs layer**					
8 =	Sal	*Salix alba*	10	–	16.6	40	33.3
8 =	Sal	*Salix fragilis*	20	–	16.6	30	41.6
x =	Sa-p	*Salix purpurea*	20	–	8.3	–	25
8 =	Sal	*Salix viminalis*	–	–	–	–	33.3
9 ~	Sa-c	*Salix cinerea*	10	20	8.3	–	–
9 ~	Al	*Salix caprea*	–	–	25	–	8.33
6	Al-U	*Acer negundo*	10	–	–	70	8.33
7 ~	Al-U	*Populus alba*	–	–	8.3	10	8.33
4	Qu	*Cornus sanguinea*	30	40	33.3	70	25
5	Qu-F	*Acer campestre*	10	20	–	–	–
x	Qu-F	*Corylus avellana*	10	20	33.3	20	–
5	Fag	*Fraxinus excelsior*	–	20	–	10	–
4	Prun	*Crataegus monogyna*	50	20	8.3	10	16.6
5	Prun	*Evonymus europaeus*	20	60	25	50	16.6
4	Prun	*Evonymus verrucosa*	10	20	–	–	–
4	Prun	*Prunus spinosa*	20	40	–	20	–
4	Prun	*Ligustrum vulgare*	–	20	–	10	–
4	Prun	*Rosa canina*	10	20	8.3	–	–
x	x	*Rubus caesius*	60	60	50	60	66.6
5	x	*Sambucus nigra*	40	40	50	60	33.3
U/W	Cenol.	**Regeneration**					
8 =	Sal	*Salix alba*	10	–	–	10	–
8 =	Sal	*Salix triandra*	20	–	–	–	–
8 =	Sal	*Salix fragilis*	10	–	–	10	8.33
x =	Sa-p	*Salix purpurea*	20	–	–	10	8.33
4	Qu	*Cornus sanguinea*	10	20	8.3	–	8.33
4	Prun	*Crataegus monogyna*	20	–	8.3	–	–
U/W	Cenol.	**Lianas**					
8 =	Sa-AU	*Humulus lupulus* (N8)	30	40	33.3	50	16.6
9 =	Sal,Se	*Cucubalus baccifer*, climbing	–	60	25	–	–
8 =	Sal	*Echinocystis lobata*	–	–	–	10	33.3
6	Cal	*Calystegia sepium* (N9)	20	60	41.6	40	66.6
–	Cal	*Partenocyssus quinquefolia*	10	–	8.3	10	8.33
8 =	x	*Solanum dulcamara* (N8)	10	–	16.6	–	–
5	Prun	*Clematis vitalba*		20	25	20	50
U/W	Cenol.	**Tall herbaceous layer**					
8	Al-U	*Equisetum telmateja* (N8)	40	20	16.6	20	–
7	Cal	*Eupatorium cannabinum* (N8)	10	20	25	10	8.33
8 ~	Cal	*Sonchus palustris*	10	20	25	–	16.6
6	Cal	*Helianthus decapetalus* (N8)	–	–	25	60	8.33
6 ~	Arct	*Conium maculatum* (N8)	40	80	41.6	20	33.3
8 =	Aeg	*Petasites hybridus* (N8)	90	20	75	10	33.3
8 =	Ad	*Telekia speciosa*	–	–	8.3	–	–
6	Art	*Dipsacus laciniatus* (N 8)	10	40	25	20	–
5	Art	*Inula helenium*	10	60	8,3	10	16,6
x	Art, Cal	*Solidago canadensis*	10	–	16.6	–	–
6	Art, Cal	*Aster lanceolatus* (N8)	–	–	–	–	33.3
8 =	x	*Polygonum cuspidatum*	10	–	16.6	20	–

Table 3 (continued): Riparian forest association Salicetum albae fragilis.

		Column/stream stretch	1	2	3	4	5
		Number of samples	10	5	12	10	12
		Frequency %	F	F	F	F	F
U/W	Cenol.	**Herbaceous layer**					
7	Al-U	*Festuca gigantea*	20	20	8.3	20	25
7	Al-U	*Stachys sylvatica*	10	20	8.3	10	–
6	Fag	*Salvia glutinosa*	10	–	16.6	30	25
5	Fag	*Pulmonaria officinalis*	20	–	8.3	10	–
5	Fag	*Viola reichenbachiana*	10	20	25	20	–
5	Fag	*Geum urbanum*	20	20	58.3	40	25
5	Qu-F	*Brachypodium sylvaticum*	50	60	25	80	16.6
x ~	Nan	*Centaurium pulchellum*	10	–	–	–	–
7 =	Cyp	*Cyperus fuscus*	10	–	–	–	–
8 ~	Calth	*Cirsium canum*	10	60	8.3	–	8.33
8	Calth	*Scirpus sylvaticus*	30	20	25	30	41.6
7	Calth	*Cirsium oleraceum*	60	40	91.6	70	33.3
8 ~	Calth	*Myosotis scorpioides*	20	20	–	–	25
7	x	*Symphytum officinale* (N8)	70	40	8.3	30	25
8 =	Cal, Sal	*Myosoton aquaticum* (N8)	40	20	25	50	16.6
8 =	Cal	*Epilobium hirsutum*	30	–	–	10	8.33
9 =	Cal	*Scrophularia alata* (N8)	20	–	8.3	10	–
8 =	Ag-Ru	*Mentha longifolia*	50	20	8.3	–	–
7 ~	Ag_Ru	*Agrostis stolonifera*	30	–	25	20	33.3
x ~	Agr-alia	*Elymus repens*	60	20	66.6	80	25
8 ~	Fil	*Valeriana officinalis*	10	20	16.6	–	–
8 ~	Fil	*Lythrum salicaria*	10	10	8.3	10	25
7	Mol	*Selinum carvifolia*	–	40	–	–	–
7	Mol	*Juncus effusus*	30	–	–	–	25
8	Mol	*Angelica sylvestris*	20	20	8.3	20	8.33
4	Arrh	*Achillea millefolium*	–	80	8.3	20	16.6
5	Arrh	*Heracleum sphondylium* (N8)	10	20	16.6	–	16.6
5	Arrh	*Anthriscus sylvestris* (N8)	–	20	41.6	–	–
5	Mo-Ar	*Prunella vulgaris*	30	–	8.3	10	8.33
6	Mo-Ar	*Vicia cracca*	40	60	25	30	8.33
5	Cyn	*Trifolium repens*	30	–	8,3	20	16.6
7 ~	x	*Deschampsia caespitosa*	10	–	–	10	8.33
4	Trif-m	*Agrimonia eupatoria*	10	40	8.3	10	–
5	Trif-m	*Geranium phaeum*	10	20	8.3	10	8.33
6	Art	*Silene alba*	10	40	41.6	40	33.3
6	Art	*Artemisia vulgaris* (N8)	50	80	33.3	40	33.3
6	Art	*Erigeron annuus* (N8)	20	–	50	20	41.6
x	Art	*Galium aparine* (N8)	20	60	8.3	20	16.6
5	Glec	*Chelidonium majus* (N8)	–	–	16,6	30	–
6	Glec	*Glecoma hederacea*	20	20	16.6	60	26.6
5	Glec	*Alliaria petiolata* (N9)	20	40	8.3	10	–
6	Glec	*Sisymbrium strictissimum*	10	60	33.3	40	8.33
7	All-ion	*Geranium robertianum*	10	20	8.3	–	–
5	All-ion	*Lapsana communis*	–	20	16.6	10	8.33

Table 3 (continued): Riparian forest association Salicetum albae fragilis.

U/W	Cenol.	**Herbaceous layer**					
6	Aeg	*Aegopodium podagraria* (N8)	60	80	58.3	8	50
5	Arct	*Arctium lappa* (N9)	20	40	50	60	33.3
6	Arct	*Lamium album* (N9)	10	20	16.6	20	–
5	Arct	*Ballota nigra* (N8)	–	20	8.3	10	–
4	Onop	*Carduus acanthoides*	40	20	8.3	–	25
5	Dau-Me	*Tanacetum vulgare*	10	–	8.3	–	8.33
4	Dau-Me	*Daucus carota*	10	–	16.6	20	8.33
3	Dau-Me	*Melilotus officinalis*	20	40	8.3	10	–
3 ~	Dau-Me	*Senecio erucifolius*	10	60	–	10	–
4	Dau-Me	*Pastinaca sativa*	30	40	33.3	20	8.33
5 ~	Pol-Che	*Sonchus arvensis*	30	20	16.6	10	25
5	Pol-Che	*Galinsoga parviflora* (N8)	–	–	16.6	10	16.6
4	Che	*Chenopodium album*	10	20	8.3	10	–
4	Sec	*Lactuca serriola*	20	20	25	–	8.33
5	Sec	*Fallopia convolvulus*	10	–	8.3	20	8.33
4	Sis	*Bromus sterilis*	10	–	8.3	–	8.33
8 =	Bid	*Polygonum hydropiper*	20	–	25	20	33.3
6 ~	dist	*Tussilago farfara*	20	20	50	40	25
4	disturb	*Cichorium intybus*	–	20	16.6	20	25
10	Phrag	*Alisma plantago-aquatica*	20	–	8.3	–	16.6
10	Phrag	*Sium latifolium*	10	20	8.3	–	–
9 =	Phrag	*Poa palustris*	20	–	16.6	–	8.33
9 =	Phrag	*Lycopus europaeus*	30	–	8.3	10	25
9 =	Phrag	*Mentha aquatica*	20	–	8.3	10	–
10	Phrag	*Phragmites australis*	40	60	41.6	50	50
9 =	Ma-Car	*Carex riparia*	–	20	–	–	16.6
10	Sp-Glyc	*Veronica beccabunga*	–	–	25	10	8.33
5	x	*Vicia sepium*	10	–	8.3	10	8.33
5	x	*Galeopsis speciosa* (N8)	40	40	41.6	30	33.3
6	x	*Urtica dioica* (N9)	60	60	83.3	70	41.6
7 ~	x	*Ranunculus repens*	20	–	16.6	50	50
8 ~	x	*Lysimachia vulgaris*	10	40	8.3	–	8.33
5	x	*Dactylis glomerata*	50	–	33	40	25
5	x	*Taraxacum officinale* (N8)	20	–	8.3	20	25

Abbreviations for the phytoceonological units given in the table: Ad = Adenostylion, Aeg = Aegopodion, Ag-Ru = Agropyro-Rumicion, Agr-alia = Agropyretalia, All-ion = Alliarion, Al-U = Alno-Ulmion, Arct = Arction lappae, Arrh =Arrhenateretalia, Art = Artemisietea, Bid = Bidention, Calth = Calthion, Cal = Calystegion and Calystegietalia, Che = Chenopodietea, Cyn = Cynosurion, Cyp = Cyperetalia fusci, Dau-Me = Dauco-Melilotion, Fag = Fagetalia, Fil = Filipendulion, Glec = Glecometalia, Ma-Car = Magnocaricion, Mo = Molinietalia, Mo-Ar = Molinio Arrhenatheretea, Nan = Nanocyperion, Onop = Onopordetalia, Pol-Che = Polygono-Chenopodietalia, Phrag = Phragmition and Phragmitetalia, Prun = Prunetalia, Qu = Quercetalia, Qu-F = Querco-Fagetea, Sa-AU = Salicion and Alno-Ulmion, Sa-c = Salicion cinereae Sal = Salicion, Sa-p = Salicetalia purpureae, Se = Senecion fluviatilis, Sec = Secalietea, Sp-Glyc = Sparganio-Glycerion, Sis = Sisymbrion, Ti-Ac = Tilio-Acerion, Trif-m = Trifolion medii.

The indicator values for nitrogen are given in parentheses beside the respective species of the synthetic table: value 8 for the distinct indicator species and value 9 for excessive nitrogen-rich sites.

Column 1: 10 samples from the Upper Scroafa Stream stretch: six samples from Roadeș, 11.07, 2013, four samples from Bunești with a dynamic island (20.08.2013); Column 2: five samples from the stretch between Bunești and Criț (11.07.2013) including the tributary streams "Pârâul de la Lunca Popii" and "Valea Lacului" (28.08.2013); Column 3: 12 samples: 1 from the village Criț (11.07.2013), six from different points Meșendorf (28.08.2013), one Daia Stream with Zaifan (13.08.2015), one Pârâul lui Müller (27.08.2013), two Scroafa Stream around the confluence with "Pârâul lui Müller" (13.08.2013); Column 4: 10 samples: two from Mihai Viteazu (11.07.2013); three from Cloașterf (two from 28.08.2013, one from 13.08.2015); Column 5: 12 samples: three from Pârâul Feleac (27.08.2013); four from Archita Stream (27.08.2013), four from the confluence area of Archita and Scroafa streams, one from the Scroafa Stream near to Vânători (5.09.2017).

Human impact and changing ecological conditions

As part of an old cultural landscape, the watercourses were from the beginning of the settlements a focus of the people. It was in the conscience to live with the water, to use it, but at the same time to save it as a common good. Over the centuries, the people used the local resources. However, the progress in industry and agriculture with growing technical knowledge changed the old systems and is unfortunately related to aspects of the environment, which suffer most from a lack of understanding the complex interrelation between ecosystems and human activity.

During fieldwork, we stated notable human impacts. Most of them are related to the deposition of waste on the streams, probably with the thinking, that the water will transport it. The category of wastes range from many types of plastic waste, garbage from the household, iron sheets, clothes and other textiles, old shoes, tatters, etc. This type of waste deposition has been stated in most localities, but in particular on the Scroafa Stream and to a lesser extent on the tributaries. Another type of deposition is related to demolition waste like bricks, concrete, rests of furniture and burning on resting places, near sheepherder cottages, etc. (Fig. 6).

Figure 6: Willow stand of natural regeneration under considerable human impact (with burning and cutting) on the lower Scroafa Stream.

Remarkable quantities of sheep wool were also observed, a consequence of the lack of former use of the sheep wool. All these depositions are an important factor for the reduction of the water quality, eutrophication and the possibility to use it. The waste deposition is a problem for the eutrophication and the colonization of many nitrophilous species (Tab. 3), including some invasive neophytes, such as for example the ash leaved maple (*Acer negundo*), the thinleaf sunflower (*Helianthus decapetalus*), white panicle aster (*Aster lanceolatus*) and Canadian goldenrod (*Solidago canadensis*).

Apart from waste depositions, which can be reduced, other problems affecting the riparian galleries are the illegal cutting of wood mostly for heating. The illegal wastewater sewage from households is also a problem mostly for Saschiz locality. However, directly for the riparian gallery forests and their survival, another important question is arising. This is the decreasing discharge and low water levels in the last years (in particular the year 2018 in the study time) and total lack of water for a longer time in the very small streams. The lack of water and the dynamics impedes the natural regeneration of the softwood forest galleries.

Under these conditions we have to put forward the question, what can be the future of the gallery willow forests along the streams, if they lack in water, of flooding and hydromorphological dynamics and as a consequence a lack of bare river banks for regeneration? Moreover, what will happen with the existing main constitutive trees during further increasing temperatures and continuous dryness? From these questions, comes another concerning the choice of trees supporting in the time of climate changes less water and higher temperatures? These questions are of actuality and need researches for an appropriate solution. Monitoring is essential for the survival of the softwood gallery forests, as important elements in the traditional Transylvanian landscape and for the floodplain forests in general.

CONCLUSIONS

Along the whole course of the Scroafa Stream, the following can be observed riparian structures, gallery-like softwood forest stands built by white willow (*Salix alba*) and brittle willow (*Salix fragilis*) in different proportion of abundance and dominance. In many sites, the brittle willow is more dominant than the white willow. Together with these dominant species locally also almond-leaf willow (*Salix triandra*), basket willow (*Salix viminalis*) all characteristic for the habitat type 91E occur. Sporadically goat willow (*Salix caprea*) and common sallow or grey willow (*Salix cinerea*) are present. On open, sandy and gravel sites the characteristic pioneer species purple willow (*Salix purpurea*) have possibilities for regeneration as, for example, downstream of the village Roadeș where open gravel banks offer appropriate conditions for the regeneration of riparian willow stands. In addition, downstream Saschiz in the "Rora" area there are as well appropriate conditions for regeneration of willow stands, but unfortunately, in that area, the human impact is given by intensive use for sheep farming with related burning and water pollution.

The hardwood floodplain forest of the habitat type 91 F0, characteristic of large river plains, are scarcely represented in the Scroafa Basin. Only small belts and groups of hardwood species such as the common oak (*Quercus robur*), field elm (*Ulmus minor*), field maple (*Acer campestre*), common ash (*Fraxinus excelsior*), and on one place of the Scroafa River bank near Buneşti, the narrow-leafed ash (*Fraxinus angustifolia*) occurs. In some cases a tendency for evolution to a forest of bird cherry (*Prunus padus*) and common ash, phytocoenoses of the Pruno-Fraxinetum association as well part of the habitat type 91E0. Between the characteristic shrubs, frequent species are the bloodtwig or common dogwood (*Cornus sanguinea*), the hazelbush (*Corylus avellana*), and the spindle bushes (*Euonymus europaea* and *Euonymus verrucosa*), less frequent being the privet (*Ligustrum vulgare*).

There are here and there, along the riparian galleries of the Scroafa Stream and its tributaries, tall herbaceous species with various dominance such as those of butter burr (*Petasites hybridus*) and hemp agrimony (*Eupatorium cannabinum*), locally with giant horsefall (*Equisetum telmateja*). These are of the habitat type 6430 of the European Union (Gafta and Mountford, 2008; EUR28, 2013). Invasive alien tall herbaceous species are present only in places where the agricultural lands are near the riparian forests. Nevertheless, these neophytes are in expansion.

The climate change and dryness of the last years have had a negative effect for the healthy state of the softwood galleries, as the trees have a decreasing vitality and are partly infested by micromycetes destroying the bark and giving the trees an aspect of black, burned branches. These phenomena were also observed in the years 2018 and 2019 on other streams of the Transylvanian Tableland as a generally dangerous aspect for the health of the riparian galleries and their future.

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POLLINATION ECOLOGY OF *HIBISCUS TILIACEUS* L. (MALVACEAE), AN EVERGREEN TREE SPECIES VALUABLE IN COASTAL AND INLAND ECO-RESTORATION

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ABSTRACT

Hibiscus tiliaceus is an amphibious evergreen tree species which grows naturally in coastal and terrestrial habitats. Flowering and fruiting is mostly seasonal. It is self-compatible, protandrous, ambophilous involving melittophily and anemophily, and hydrochorous. Melittophily involves certain bees, which effect sternotribic pollination. Anemophily is functional only during the afternoon period. Delayed autonomous autogamy, a characteristic of the Malvaceae family, is not functional in this species. The tree has dual modes of regeneration, by seed and by sprouting prostrate stems. It is a most suitable species for coastal and inland eco-restoration.

ZUSAMMENFASSUNG: Bestäubungsökologie der immergrünen Baumart *Hybiscus tiliaceus* L. (Malvaceae), von Bedeutung für ökologische Renaturierung an Küsten und im Binnenland.

Hibiscus tiliaceus ist eine amphibische immergrüne Baumart, die natürlicher Weise an Küsten- und in Landlebensräumen wächst. Blüte und Früchte sind meistens saisonal. Sie ist selbstverträglich, protandrisch, ambophil, melittophil, anemophil und hydrochor. Die Melittophilie betrifft bestimmte Bienenarten, die sternotribische Bestäubungzur Folge haben. Die Anemophilie funktioniert nur während des Nachmittags. Verzögerte Selbstbestäubung, ein Merkmal der Malvaceaen, funktioniert nicht bei dieser Art. Der Baum hat zwei Arten von Regeneration und zwar durch Samen und durch Sprießen von Stängeln. Es ist eine sehr wertvolle Art für die ökologische Renaturierung der Küsten-und des nahen Binnenlandes.

REZUMAT: Ecologia polenizării la *Hybiscus tiliaceus* L. (Malvaceae), specie arboricolă sempervirescentă de importanță pentru refacerea ecologică a coastelor și a ariilor terestre.

Hibiscus tiliaceus este o specie arboricolă perenă amfibie, care crește în mod natural în habitate costiere și terestre. Înflorirea și fructificarea este, de obicei, sezonieră. Este auto-compatibilă, protandrică, ambofilă, care include melitofilie, anemofilie și hidrochorie. Melitofilia este caracteristică pentru anumite albine, care influențează polenizarea sternotribică. Anemofilia funcționează doar după-amiaza. Autogamia autonomă întârziată, caracteristică pentru familia Malvaceae nu funcționează la această specie. Arborele are două modalități de regenerare și anume, prin semințe și prin lăstărirea tulpinilor. Este o specie ideală pentru refacerea ecologică a zonelor costiere și terestre interioare.

INTRODUCTION

Pollination enables fertilization and seed production but its occurrence is largely dependent on external agents such as animals and wind (Maddala and Aluri, 2019). However, plants themselves resort to self-pollination having failed to achieve pollination by external agents (Barrows, 2011). Pollination ecology data are critical in dealing with effects of human changes to the habitats of plants (Hopper and Burbidge, 1986; Brown et al., 1997). Therefore, pollination ecology is most vital for seed production and subsequent recruitment of offspring and expansion of distribution of individual plant species in a variety of suitable habitats.

The genus *Hibiscus* comprises 200-300 species, distributed chiefly in tropical and subtropical regions (Pfeil et al., 2002). Of these, some species occur in open habitats along riverbanks and in freshwater wetlands, while others occur along brackish tidal and coastal wetlands (Tomlinson, 1986). *Hibiscus tiliaceus* is a pantropical coastal tree that extends to the tidal zone, inhabiting highly contrasting littoral and terrestrial habitats (Tomlinson, 1986). Wang and Wang (1999) noted that this tree species occurs commonly along the seashore, where the substrate salinity is relatively high. Santiago et al. (2000) noted that *H. tiliaceus* occurs in the most landward fringe of mangrove forests and also grows along freshwater streams or in upland forests, where soil salinity is negligible. Tang et al. (2011) reported that estuarine populations of *H. tiliaceus* are genetically more variable than the inland populations. This genetic diversity is correlated with population size; the estuarine populations do not consistently have a greater population size than the inland populations. Genetic variation in estuarine populations has been related to migrant sea-drift seed dispersal because the possibility for this form of seed dispersal is quite extensive in estuarine zones.

In Malvaceae, the flowers are hermaphroditic and entomophilous (Tang et al., 2007). Wind pollination is unlikely, as the pollen grains are sticky and tend to clump together (Spira, 1989). Most Malvaceae are self-compatible and capable of delayed selfing, having flowers with styles that are surrounded by and extend beyond monadelphus stamens (Klips and Snow, 1997; Kumar et al., 2014). In these species, the styles curve out and backwards as flowers age, until the stigmas contact pollen located in the upper anthers (Kumar et al., 2014).

Few data are available on *Hibiscus* pollination ecology. Buttrose et al. (1977) noted that *H. trionum* uses stylar movements as a mechanism to facilitate self pollination as an option if cross-pollination is failed. Willemstein (1987) noted that *H. trionum* is mainly pollinated by higher bees and pollen-feeding flies but, it is melittophilous. *H. laevis* is self-compatible (Klips and Snow, 1997) and uses stylar movements as a mechanism to foster out-crossing by putting the stigmas in the flight path of nectar-seeking bees subsequent to a predominantly male phase of anthesis during which the stigmas are held together and project forward (Stephens, 1948). This species is pollinated by bumblebees and oligolectic bees (Ruan, 2010). *H. moscheutos* is self-compatible and herkogamous, preventing self-pollination but not geitonogamy (Spira, 1989). The pollinators use petals as a cue to locate the flowers of *H. moscheutos* and the plant is pollinated by anthophorid bees and bumblebees (Snow and Spira, 1993; Kodoh and Wigham, 1998). *H. tiliaceus* is pollinated by an endemic Galapagos carpenter bee, *Xylocopa darwini*, which also nests in this tree (Williams, 1926). This carpenter bee pollinates *H. tiliaceus* in the littoral of the Galapagos (McMullen, 1989). Later, Hamrick and Godt (1990) noted that *H. tiliaceus* is insect-pollinated. The data on the pollination ecology of *Hibiscus* is incomplete to understand the sexual reproduction, starting from the floral biology to seed dispersal and regeneration. With this background and absence of pollination studies on *H. tiliaceus* in India, the present study has been carried out to provide details of the pollination ecology of *H. tiliaceus* to enable other reaserchers to take up similar work in the entire range of this species for its use in coastal eco-restoration projects.

MATERIAL AND METHODS

H. tiliaceus trees growing along the coastlines and in inland terrestrial sites in Visakhapatnam, Andhra Pradesh, S.E. India (17°42'N Latitude and 82°18'E Longitude) were selected for the study during June 2018-May 2019.

Regular visits to these trees were made to record flowering and fruiting seasons. Ten inflorescences, which were about to initiate flowering on five plants were tagged and followed to record the flower-opening schedule and the timing and mode of anther dehiscence. Anther dehiscence timing was confirmed by observing the anthers, under a 10x hand lens. Twenty fresh flowers were used to record the floral morphological aspects, flower type, sex, shape, colour, symmetry, calyx, corolla, stamens, ovary, style and stigma. The floral configuration and rewards presentation aspects were observed in relation to the probing and forage collection of activities of insects. Ten mature buds two each on five plants were bagged and tagged to measure nectar volume and sugar concentration using the protocols provided by Dafni et al. (2005). The micropipette was inserted into the flower base to extract nectar for measurement. The average nectar of ten flowers was taken as the total volume of nectar/flower and expressed in µl. Hand Sugar Refractometer (Erma, Japan) was used for this purpose. Nectar analysis for sugar types was performed as per the Paper Chromatography method described by Dafni et al. (2005). The stigma receptivity was observed visually and by H_2O_2 test. In visual method, the stigma physical state was considered to record its receptivity duration. H_2O_2 test as given in Dafni et al. (2005) was followed for the confirmation of the stigma receptivity period. Insects foraging at the flowers were observed throughout the day on three different days for their mode of approach, landing, probing behaviour and contact with the floral sexual organs. Fruit maturation period, the fruit and seed characteristics were recorded. Field observations were made to record fruit/seed dispersal mode. Casual observations were also made to record whether the seeds after their dispersal germinate immediately or not.

RESULTS

H. tiliaceus is a coastal, fast-growing evergreen tree that occurs along the shoreline and in the landward fringe of mangrove forest, where soil salinity varies from high to low and along freshwater streams, where soil salinity is negligible (Fig. 1a). It regenerates quickly from branches that touch the soil and form roots. It also propagates through seed, which is produced from sexual reproduction. The plants produced from vegetative propagation bloom within a year, while those produced from seeds bloom in the second or third year depending on the habitat where they grow. Field observations along the coastline showed that this tree is important for the stabilization of sand dunes and coastal wind breaks and as a living fence post. Furthermore, it is also cultivated in inland garden landscapes as an ornamental tree for shade purposes. It produces a short trunk with several twisted and spreading branches, forming impassable thicket. The leaves are simple, alternate, heart-shaped, wavy and slightly hairy, with leaf-like stipules at the base of the petiole (Fig. 1b).

The plant flowers from October to January, but sporadic flowering occurs throughout the year (Fig. 1c). The flowers are borne in three- to six-flowered cymes and occasionally are solitary in axillary and terminal positions. The buds stay almost erect during the mature and immature stages, and attain a down-hanging position upon anthesis and stay away from the foliage, without any contact between flowers and leaves. They are bright yellow, showy, large, hermaphroditic and fragile, and they fall at the end of the same day on which they open. Individual flowers are pedicellate, cup-shaped, with the calyx consisting of five elongate-triangular light greenish sepals and corolla consisting of five radiating obovate free petals four-six cm long, with a dark maroon base on the inside and basally adnate to the staminal tube. The staminal column is a monadelphous tube consisting of numerous united filaments basally and protruding, with low and high one-celled anthers having yellow spiny pollen; it is inserted in the centre of the flower. The most distal part of the staminal column has a red, five-partite slender style each branch terminated with a capitate stigma. The ovary is five-celled, but each cell has a false septum, making it altogether 10-celled, and each cell contains many ovules.

Mature buds open at 07,00-08,30 hrs (Figs. 1d-h). The staminal column with stamens positioned below the five-partite style segregates male and female sex organs and characterizes herkogamy. The anthers dehisce at the time of unfolding of the petals and the pollen at that time is sticky, (Fig. 1i) but it becomes dry and powdery around midday. The stigmas are receptive after anthesis and remain so, until flower fall; they are held together and stay erect, or slightly open up in a columnar form until flower fall (Figs. 1j-k). Individual flowers secrete 0.2-0.3 µl of nectar, with 28-32% sugar concentration. The flowers fade gradually from yellow to light pink towards evening and fall off without closing. The corolla, stamen-tube and upper portion of the gynoecium fall off as a single unit, while the calyx and ovary remain in place after pollination (Fig. 1l).

Figure 1: *Hibiscus tiliaceus*: a. Habit; b. Alternate leaf arrangement and leaf-like stipules at the base of the petiole; c. Flowering phase; d.-e. Buds; f.-h. Stages of anthesis; i. Height of staminal column against petals; j. Staminal column with dehisced stamens and five stigmas held together projecting forward; k. Staminal column with dehisced anthers and slightly stretched out stigmas; l. Calyx with ovary after fall of corolla together with staminal column and upper portion of gynoecium; m.-n. Initial stages of fruit development.

The showy hanging flowers against the background of green foliage are very attractive to floral visitors. The flowers were foraged by various bees – honey bees (*Apis dorsata, A. cerana, A. florea*, and *Trigona iridipennis*), carpenter bees (*Xylocopa latipes* and *Ceratina simillima*) and leaf-cutter bees (*Megachile* sp.). Of these, *X. latipes* foraged for only nectar, while all others foraged for both nectar and pollen. Their foraging intensity was found to be dependent on the number of flowers available on any given day. The bees usually landed on upturned stigmas, and then moved towards the base of the flower by walking through the pollen-laden anthers to probe for nectar and simultaneously, they collected pollen. The dark maroon corolla base appeared to be serving as nectar guide, to guide the bees to access nectar. After forage collection, they departed from the flower by walking on the petals without touching the stigmas again. In this flower-probing behaviour, if the bees carried pollen from the previously visited flower, then they transferred it to the stigmas effecting cross-pollination. Their first visits to flowers made them as pollen carriers only without effecting pollination. Occasionally, the bees, especially *A. florea* and *T. iridipennis*, landed on the petals and walked towards the flower base to collect nectar and after its collection, they made a U-turn and walked on the staminal column to collect pollen; then they departed from the flower with or without touching the stigmas. In these foraging behaviours, the bees contacted the pollen with their ventral side effecting sternotribic pollination.

Wind shakes the branches of the tree, causing the dry and powdery pollen available in flowers around midday to fall on the stigmas of the same flowers, easily effecting self-pollination due to the hanging position of flowers. Depending on the wind speed, which is very high at certain times along the coast, some of this dispersed pollen could reach the stigmas of other flowers of the same or different conspecific plant to effect cross-pollination.

The fruit is an ovoid to ellipsoid, light brown dry loculicidal capsule 2.5-3 cm long, with 30-50 seeds. Fruits mature within 5-7 weeks after pollination (Fig. 1l-m) and split apart into five two-celled segments to release seeds (Figs. 2a.-b.). However, the calyx and involucre remain attached with some leftover seed which could not be dispersed or had fallen to the ground by gravity (Fig. 2c). Seed are brownish-black, rough-coated, 4 x 2 mm and hairless; they are dispersed in inland habitats by rainwater during the rainy season and float in seawater, remaining viable for more than three months. The air space within the thick water-impermeable seed coat enables the seeds to float. In inland habitats, seeds germinate during the rainy season and produce new plants.

Figure 2: *Hibiscus tiliaceus:* a.-b. Loculicidal capsule dehiscence and seed dispersal; c. Capsule still in place after seed dispersal.

DISCUSSION

The genus *Hibiscus* is chiefly tropical and subtropical in distribution. Its species occur either in open habitats along riverbanks and in freshwater wetlands, or in brackish tidal and coastal wetlands (Pfeil et al., 2002). *H. tiliaceaus* grows in littoral and terrestrial habitats (Tomlinson, 1986), along the seashore habitats, where the substrate salinity is relatively high (Wang and Wang, 1999), in the most landward fringe of mangrove forests and along freshwater streams or in upland forests, where soil salinity is negligible (Santiago et al., 2000). Furthermore, in this species estuarine populations have been reported to be tolerant to high salinity compared to upland populations (Santiago et al., 2000). Estuarine populations are small and are genetically more variable than the large inland populations, and this genetic variation in estuarine populations is linked to migrant sea-drift seed dispersal, because this form of dispersal is quite extensive here (Tang et al., 2011). The present study showed that *H. tiliaceus* grows naturally in coastal and inland wetlands as well as inland terrestrial habitats where it is usually cultivated as an ornamental tree, indicating that it is a highly versatile species to grow in both saline and non-saline habitats.

Most Malvaceae species are self-compatible and produce flowers with a monadelphous staminal tube consisting of numerous stamens, all of which, along with the style extend beyond the tube. The style is usually five-partite and each branch has a capitate stigma (Klips and Snow, 1997; Kumar et al., 2014). The styles with stigmas are held together and project forward facilitating nectar-seeking foragers to contact the stigmas first and then pass through the stamens with dehisced anthers to achieve cross-pollination. The stigmas that were not pollinated will curve out and reflex backwards to touch the upper anthers situated below to achieve selfing. This stylar movement is shown as a delayed autonomous selfing mechanism which occurs only when all opportunities for cross-pollination have passed and hence it is a fail-safe mechanism to ensure selfing in the absence of pollinators (Stephens, 1948; Klips and Snow, 1997; Kumar et al., 2014). Delayed autonomous selfing occurs in several genera of Malvaceae (Ruan et al., 2011) such as in *H. laevis* and *H. trionum* (Buttrose et al., 1977) and *H. laevis* (Stephens, 1948; Klips and Snow, 1997). The present study found that *H. tiliaceus* does not exhibit delayed selfing mechanism as the stigmas are held together and project forward through the life of the flower. The absence of mechanism of stylar curvature and movement provides equal opportunities for both cross- and self-pollination. Further, the flowers last only one day and the corolla, staminal tube and upper portion of the gynoecium fall off as a single unit in both pollinated and un-pollinated flowers, indicating that pollen tube growth through the stylar tissue is very fast to fertilize the ovules in pollinated flowers.

In Malvaceae, the flowers are hermaphroditic and entomophilous (Tang et al., 2007); pollinators include generalized pollination insects, bees and butterflies (Kodoh and Wigham, 1998). *H. trionum* is pollinated by honey bees (Willemstein, 1987), *H. laevis* by bumblebees and oligolectic bees (Ruan, 2010), and *H. moscheutos* by solitary anthophorid bees and bumblebees (Snow and Spira, 1993). In *H. moscheutos*, pollinators use petals as cue to locate the flowers (Kodoh and Wigham, 1998). *H. tiliaceus* wood is used by the carpenter bee *Xylocopa darwini*, for its nesting (Williams, 1926) and is also pollinated by the same bee in the littoral zone of the volcanic Galapagos Archipelago (McMullen, 1989). In the present study, *H. tiliaceus* flowers are bright yellow and seem to serve as a cue for the pollinating bees to locate and probe the flowers for nectar and/or pollen. The pollinators include nectar- and pollen-collecting honey bees, leaf-cutter bees and nectar-collecting carpenter bees. The bees that proceed by contacting the stigmas first and then pollen to collect pollen and nectar; this way of flower probing ensures the occurrence of cross-pollination while those that proceed skipping the staminal column to collect nectar and then pollen by walking on the staminal column may or may not effect selfing. In either way, the bees effect sternotribic pollination which involves wastage of pollen during flight and loss of pollen due to their grooming. However, this pollen loss is compensated by the production of copious pollen by individual flowers.

In Malvaceae, wind pollination is unlikely because pollen grains are sticky and tend to clump together (Spira, 1989). In *Kosteletzkya virginica*, self-pollination occurs by wind brush pollination when there is wind. When the wind shakes the branches with open flowers, contact between leaves and pollen leads some pollen to stay on the surface of leaves; after this, wind flaps the branches easily to make stigmas to touch this pollen, achieving self-pollination (Ruan, 2010). In the present study, it has been found that *H. tiliaceus* pollen is sticky initially, but gradually becomes dry and powdery around midday. Winds of various speeds facilitate pollen shedding from the anthers easily from midday and until the flowers fall and it is captured by the capitate stigmas due to its down-hanging position and achieves selfing. The spiny nature of pollen facilitates the stigmas to hold the pollen intact, ensuring pollen germination and subsequent fertilization prior to flower drop. Therefore, *H. tiliaceus* is also anemophilous, but it is largely useful for the occurrence of selfing.

Hibiscus is hydrochorous (Tomlinson, 1986). The seeds float for a few months and have dispersal potential over long distances. *H. hamabo* produces buoyant seeds which float for a long period (Nakanishi, 1988). *H. moscheutos* produces seeds which are initially dispersed by gravity and then secondarily by water during floods (Kudoh et al., 2006). In *H. tiliaceus*, the seeds float, withstand immersion in seawater and remain viable for more than three months. Its widespread distribution is attributed to seed dispersal by ocean currents (Nakanishi, 1988). The present study shows that *H. tiliaceaus* disperses seeds by splitting open of the loculicidal capsule, but it is not very effective since some seed remain attached to the vertical septa in split capsules which do not detach after their maturity and splitting. The seeds dispersed from the capsules fall to the ground by gravity and are subsequently carried away by seawater in plants along the coastline and by rainwater in plants growing in inland areas. This mode of seed dispersal indicates that seawater or freshwater is an effective medium for its widespread distribution. Further, the seed are buoyant because of the airspace inside the thick water-impermeable seed coat and remain viable for a long period during dispersal and until they find a suitable substrate for germination and growth of new plants. In inland habitats, *H. tiliaceus* does not have the opportunity to float in freshwater all the time as rains are seasonal in occurrence. In effect, the plants growing in such habitats are most likely to produce non-buoyant seeds by simply losing the airspace and having a thin water-permeable seed coat for germination in terrestrial habitats. This hypothesis is in line with the report by Kudoh et al. (2006) that *H. tiliaceus* adapted to inland habitats of the Bonin Islands produces non-buoyant seed which do not float on sea water. Furthermore, these authors noted that the immigrants of this species adapted to inland island habitats have evolved various modifications to their features to produce a new species, *H. glaber,* endemic to the islands.

Chin and Enoch (1988) reported that *H. tiliaceus* is wind- and salt-resistant and adapted to a wide range of environments. It is used for the stabilization of sand dunes and the formation of coastal wind breaks. Tang et al. (2003) mentioned that it is often cultivated inland in garden landscapes as an ornamental shade tree. The present study also reports that *H. tiliaceus* is an important evergreen tree species for coastline restoration due to its multiple uses. Since this tree species has the ability to propagate through seed and by sprouting prostrate stems, it is a most suitable species for use in eco-restoration projects for the restitution of ecologically degraded, damaged and destroyed coastal and inland ecosystems.

CONCLUSIONS

Hibiscus tiliaceus is a fast growing evergreen tree species that grows both in coastal and inland habitats. It is largely a seasonal flowerer and produces large hermaphroditic cup-shaped flowers, which are quite attractive against the background foliage. It is self-compatible, protrandrous, melittophilous, anemophilous, and hydrochorous. Its dual regeneration ability through seed and by sprouting prostrate stems ensures its widespread distribution. Further, it is an important tree species in the eco-restoration of ecologically deteriorated coastal and inland habitats.

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MICROPREDATOR BEHAVIOUR OF *ROCINELA DUMERILII* (ISOPODA, AEGIDAE) ON *TRACHURUS TRACHURUS* IN THE SEA OF MARMARA (TURKEY)

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KEYWORDS: *Rocinela dumerilii*, micropredator, *Trachurus trachurus*, *Elthusa sinuata*, the Sea of Marmara.

ABSTRACT

Rocinela dumerilii (Lucas, 1849) is obtained on the horse mackerel, *Trachurus trachurus* (Linnaeus, 1758) from the Sea of Marmara, in Turkey. This species is a free-living organism from the Aegean Sea of Turkey, the Mediterranean Sea and Atlantic. Its micropredator behaviour is discovered for the first time in this study. *Elthusa sinuata* (Koelbel, 1879) is also collected on the gill cavity of Fries's goby, *Lesueurigobius friesii* (Malm, 1874) in this study. This host is a new record for *Elthusa sinuata*. The morphological characters of *Rocinela dumerilii* species are given by drawings.

RÉSUMÉ: Le comportement microprédateur de *Rocinela dumerilii* (Isopoda, Aegidae) sur le chinchard commun *Trachurus trachurus* dans la Mer de Marmara (Turquie).

Rocinela dumerilii (Lucas, 1849) est collectée sur les exemplaires de chinchard *Trachurus trachurus* (Linnaeus, 1758) en provenant de la Mer de Marmara, en Turquie. Cette espèce est connue en tant que forme de vie libre, de la Mer Egée, en Turquie, de la Mer Méditerranée et de l'Atlantique. Son comportement micro-prédateur a été découvert pour la première fois durant cette étude. *Elthusa sinuata* (Koelbel, 1879) est également collecté de la cavité branchiale du gobie à grandes écailles, *Lesueurigobius friesii* (Malm, 1874) durant cette étude. Cet hôte est un nouveau record pour *Elthusa sinuata*. Les caractères morphologiques de l'espèce de *Rocinela dumerilii* sont indiqués par des dessins.

REZUMAT: Comportamentul microprădător al speciei *Rocinela dumerilii* (Isopoda, Aegidae) pe stavridul atlantic *Trachurus trachurus* în Marea Marmara (Turcia).

Rocinela dumerilii (Lucas, 1849) este colectată de pe exemplare de stavrid atlantic *Trachurus trachurus* (Linnaeus, 1758) din Marea Marmara, Turcia. Această specie este cunoscută ca formă de viață liberă, în Marea Egee, în Turcia, din Marea Mediterană și Atlantic. Comportamentul său microprădător a fost descoperit pentru prima dată în timpul acestui studiu. *Elthusa sinuata* (Koelbel, 1879) a fost, de asemenea, colectată din cavitatea branhială a guvidelui lui Fries, *Lesueurigobius friesii* (Malm, 1874) în timpul acestui studiu. Această gazdă este o nouă semnalare pentru *Elthusa sinuata*. Caracterele morfologice ale speciei *Rocinela dumerilii* sunt indicate prin desene.

INTRODUCTION

Members of the family Aegidae are active predators on hosts such as fish and elasmobranches (Brusca, 1983; Bruce, 2003, 2004). These isopods attack the external surfaces of fish. They were also reported as associated with invertebrates (Brusca, 1983; Bruce, 2003, 2004). They may be named as micropredators or temporary parasites. They may also act as scavengers, consuming dead fish that settle to the benthos. When not feeding, aegids lie on the substratum (Brusca and Iverson, 1985). Aegidae are distributed throughout the world oceans, from the tropics to polar waters (Bruce, 2009). Forty-one species of *Rocinela* are listed by Worms Editorial Board (2019).

There are few association records between aegids, fish, and invertebrates hosts: *Rocinela signata* was reported on the general body surface and gills of hosts such as nurse sharks (Brusca and Iverson, 1985). *R. signata* was reported from *Dasyatis americana*, *D. guttata* (Williams et al., 1994); from few fish species including *Archosargus probatocephalus*, *Balistes vetula*, *Bothus lunatus*, *Calamus calamus*, *Calamus bajonado*, *Calamus penna*, *Caranx* sp., *Dasyatis americana*, *Epinephelus itajara*, *Epinephelus morio*, *Galeocerdo cuvieri*, *Ginglymostoma cirratum*, *Haemulon steindachneri*, *Haemulon flavolineatum*, *Lachnolaimus maximus*, *Lutjanus analis*, *Lutjanus buccanella*, *Lutjanus blackfordi*, *Mycteroperca venenosa*, *Mycteroperca bonaci*, *Orthopristis ruber*, *Raja eglanteria*, *Sparisoma viride*, *Sphyraena barracuda* (Kensley and Schotte, 1989); from *Lutjanus analis*, *Micropogonias furnieri* (Bunkley-Williams and Williams, 1998). *Aega tridens* was reported from *Scomber scomber* (Treasurer, 2001); while *Aega rosacea* from *Epinephelus guaza*, *Mullus barbatus barbatus*, *Squatina squatina* and *Aega deshaysiana* from *Sardina pilchardus* (Ramdane and Trilles, 2008). Garzón-Ferreira (1990) also noted *R. signata* attacking humans in Colombia.

The *Elthusa* members are observed in the branchial cavities of hosts. 35 species belonging to this genus are listed by Worms Editorial Board (2019). It is recorded from the Indo-West Pacific, Eastern Pacific, the Atlantic, and the Mediterranean (van der Wal et al., 2019). *Elthusa sinuata* (Koelbel, 1879) is known from the Mediterranean Sea red bandfish.

Although species of *Rocinela* from Mediterranean has been reported by several researchers many times, the morphology of females and males of this genus in the Mediterranean has not been investigated. Specific key is necessary to identify the species belonging *Rocinela* genus for Mediterranean Sea.

The aim of this study is to provide a tool for taxonomists for future use. The present study contributes the presence of micropredator behavior of *R. dumerilii* on host fish and also to the knowledge of the host diversity of *Elthusa sinuata*.

MATERIAL AND METHODS

Trachurus trachurus (Linnaeus, 1758) (Fig. 1) (Perciformes, Carangidae) and *Lesueurigobius friesii* (Malm, 1874) (Fig. 2) (Perciformes, Gobiidae) were caught by trawling net in Marmara Sea, Turkey, on July 2017. Collected isopod samples were fixed in 70% ethanol. Some specimens were dissected with the use of a Wild M5 stereo microscope. The appendages were drawn with the aid of a camera lucida (Olympus BH-DA). Drawings were transfered to digital media via scanner. The photos were taken with a Canon EOS 1100D camera attached to a microscope. Measurements (in μm) were obtained using a program (Pro-way). Identifications and comparisons were performed according to Schiodte and Meinert (1879), Kussakin (1979), Monod (1923) for *R. dumerilii* and Trilles (1976), Öktener et al. (2018) for *Elthusa sinuata*. The scientific names, synonyms of parasite, and host were checked with Worms Editorial Board (2019), and Froese and Pauly (2019).

Figure 1: *Trachurus trachurus*
(Linnaeus, 1758).

Figure 2: *Elthusa sinuata* in the gill cavity
of *Lesueurigobius friesii* (Malm, 1874)
(partialy dissected).

RESULTS AND DISCUSSION

Order Isopoda Latreille, 1817
Suborder Cymothoida Wagele, 1989
Superfamily Cymothooidea Leach, 1814
Family Aegidae White, 1850
Genus *Rocinela* Leach, 1818
Rocinela dumerilii (Lucas, 1849) (Figs. 3-9)
Synonmyies *Acherusia dumerilii* Lucas, 1849; *Acherusia complanata* Grube, 1864

Rocinela dumerilii Lucas, 1849: Schiodte and Meinert, 1879; Richardson, 1898; Norman, 1904; Richardson, 1905; Norman and Scott, 1906; Monod, 1923; Duncan, 1956; Menzies and Glynn, 1968; Schultz, 1969; Kensley, 1978; Kussakin, 1979; Howson and Picton, 1997; Junoy and Castelló, 2003; Alves et al., 2006; Kırkım et al., 2006; Mansour et al., 2011; Bakır et al., 2014; Bedini et al., 2015; Sampaio et al., 2016; Ortiz and Lalana, 2018.

Figure 3: *Rocinela dumerilii* (Lucas, 1849).

Host: The Atlantic horse mackerel, *Trachurus trachurus* (Linnaeus, 1758).
Infestation site: body surface. Infestation tissue: skin.
Sampling stations: 40°31’N-28°12’E; 40°33’N-27°52’E; 40°26’N-27°36’E.

Description. Body (14.9, 15.3, 16.9 mm) 2.4-2.6 times as long as max. width, widest at pereonite four, lateral margins subparallel. Eyes not united, separated by 9-10% width of head; each eye made up of ~13 transverse rows of ommatidia, each row with ~nine ommatidia; black eyes. Pleon with pleonite one largely concealed by pereonite seven, or visible in dorsal view; pleonite four with posterolateral margins extending beyond posterior margin of pleonite five; pleonite five with posterolateral angles acute. Pleotelson 0.8 times as long as anterior width.

Antennule peduncle article three, 0.7 times as long as combined lengths of articles one and two, 2.3 times as long as wide; flagellum with six articles, not extending to anterior of pereonite one. Antenna peduncle article three, three times as long as article two, 1.1 times as long as wide; article four 4, 1.3 times as long as article three, 1.5 times as long as wide, inferior margin with one simple seta; article five, 1.4 times as long as article four, 2.4 times as long as wide, inferior margin with one seta, anterodistal angle with cluster of three short simple setae; flagellum with 15 articles, extending to posterior of pereonite one.

Mandible molar process is a flat lobe; palp article two with seven short marginal distolateral setae and two long distolateral setae; palp article three with 16 setae. Maxillule with six RS/robust spine (one large, five slender, without serrate). Maxilla mesial lobe with two RS; lateral lobe with two RS. Maxilliped palp article one distomesial angle with three RS (with thin one seta betwen two large setae); article two with three hooked RS (with one thin and two large setae); article three with one hooked RS (article three fused to article two).

Pereopod one basis 2.3 times as long as greatest width; ischium three times as long as basis, inferior margin with zero RS and inferrodistal angle with two spines, superior distal margin with one seta; ischium superior distal angle with two setae and inferodistal angle with one seta; merus inferior margin with four RS and one small spine, superior distal angle with three setae; carpus 0.7 as long as merus, inferior margin with one RS (minute); propodus 1.2 times as long as proximal width, propodal palm with blade, propodal blade 0.6 times as wide as palm, inferior margin with four RS; dactylus 1.2 times as long as propodus. Pereopods two and three similar to pereopod one (but RS on merus longer). Pereopods six and seven similar.

Pereopod seven basis 2.9 times as long as greatest width, inferior margins with 10 palmate setae; ischium 0.8 as long as basis, inferior margin with four RS, superior distal angle with three RS, inferior distal angle with four RS; merus 0.5 times as long as ischium, 2.1 times as long as wide, inferior margin with one RS, superior distal angle with five RS, inferior distal angle with four RS; carpus 0.6 as long as ischium, 2.5 times as long as wide, inferior margin with two RS, superior distal angle with eight RS (two setae), inferior distal angle with six RS; propodus 0.5 long as ischium, 4.0 long as wide, inferior margin with three RS, superior distal angle with two long and two short setae and one palme seta, inferior distal angle with two RS.

Pleopod one exopod 1.9 times as long as wide, with PMS/plumose seta on right lateral margin, with PMS on two-thirds of left lateral margin; mesial margin weakly convex, with PMS; endopod 2.2 times as long as wide, lateral margin weakly concave, with PMS on two-third of left margin, without PMS on right margin; mesial margin with PMS; peduncle mesial margin with five-six coupling hooks. Pleopods two-four peduncle mesial margin with five-six coupling hooks, lateral margin with PMS. Uropod peduncle ventrolateral margin with two RS and five-seven PMS, posterior lobe half long as endopod. Exopod rami not extending to pleotelson apex. Endopod lateral margin convex, lateral margin with five RS, mesial margin distally rounded, with five RS. Exopod not extending to endopod end, 3.2 times long as maximum width; lateral margin convex, with eight RS; mesial margin straight, distally convex, with zero RS; distal margin with indistinct apex.

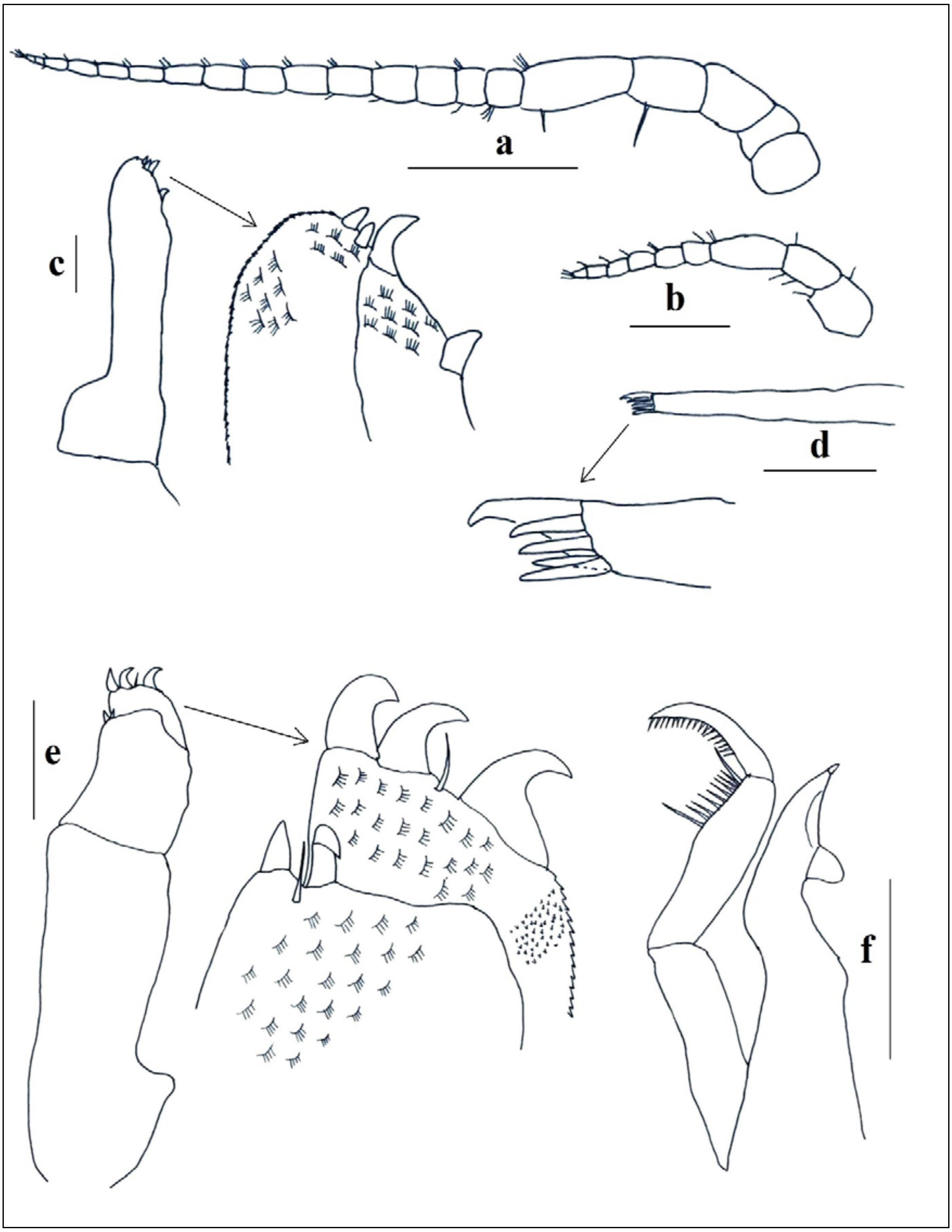

Figure 4: *Rocinela dumerilii* a. antenna (1.31 mm), b. antennule (0.8 mm), c. maxilla (0.16 mm), d. maxillule (0.37 mm), e. maxilliped (0.37 mm), f. mandible (0.57 mm).

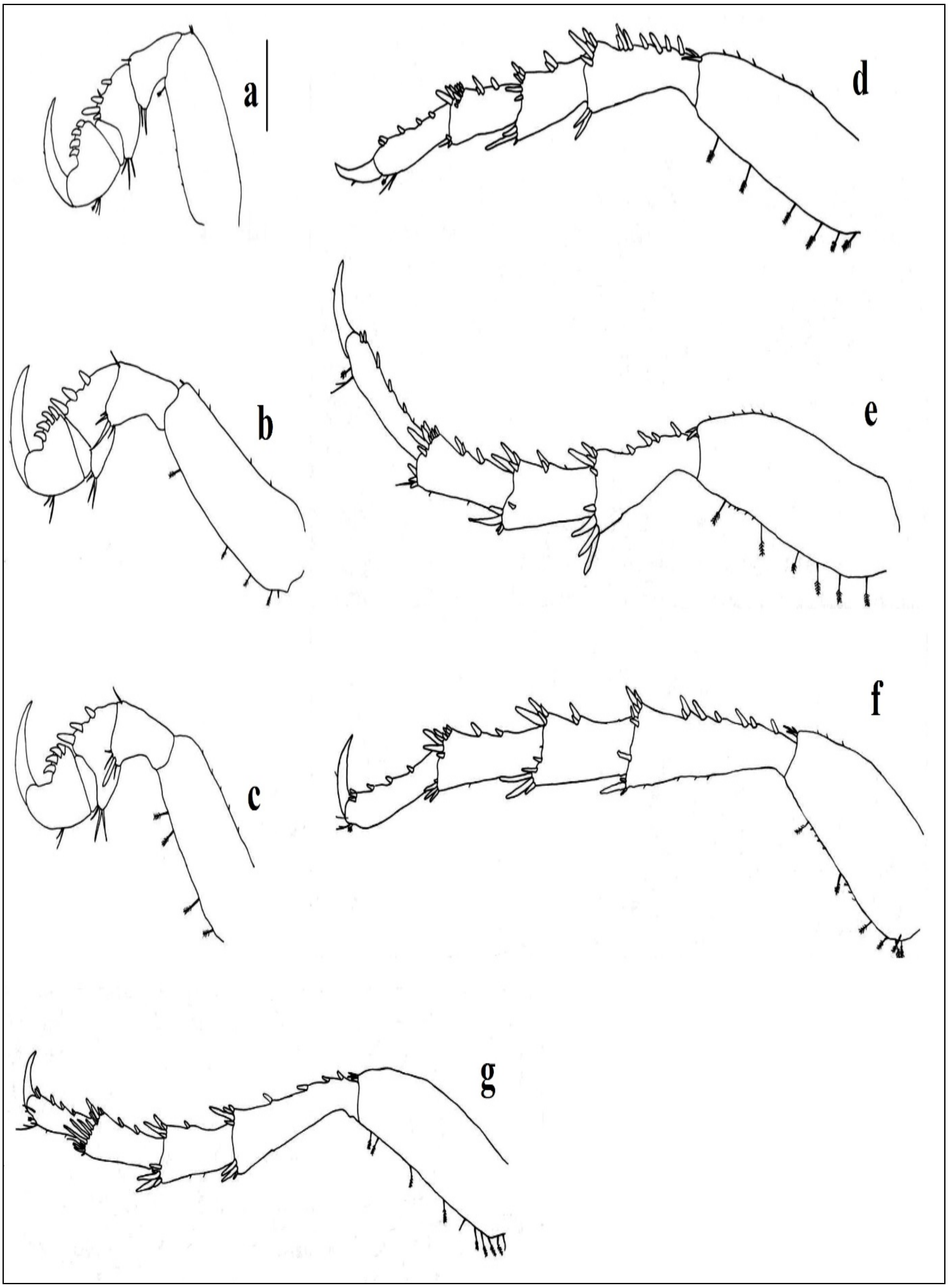

Figure 5: *Rocinela dumerilii* (a-g),
Pereopods 1-7 (0.66 mm).

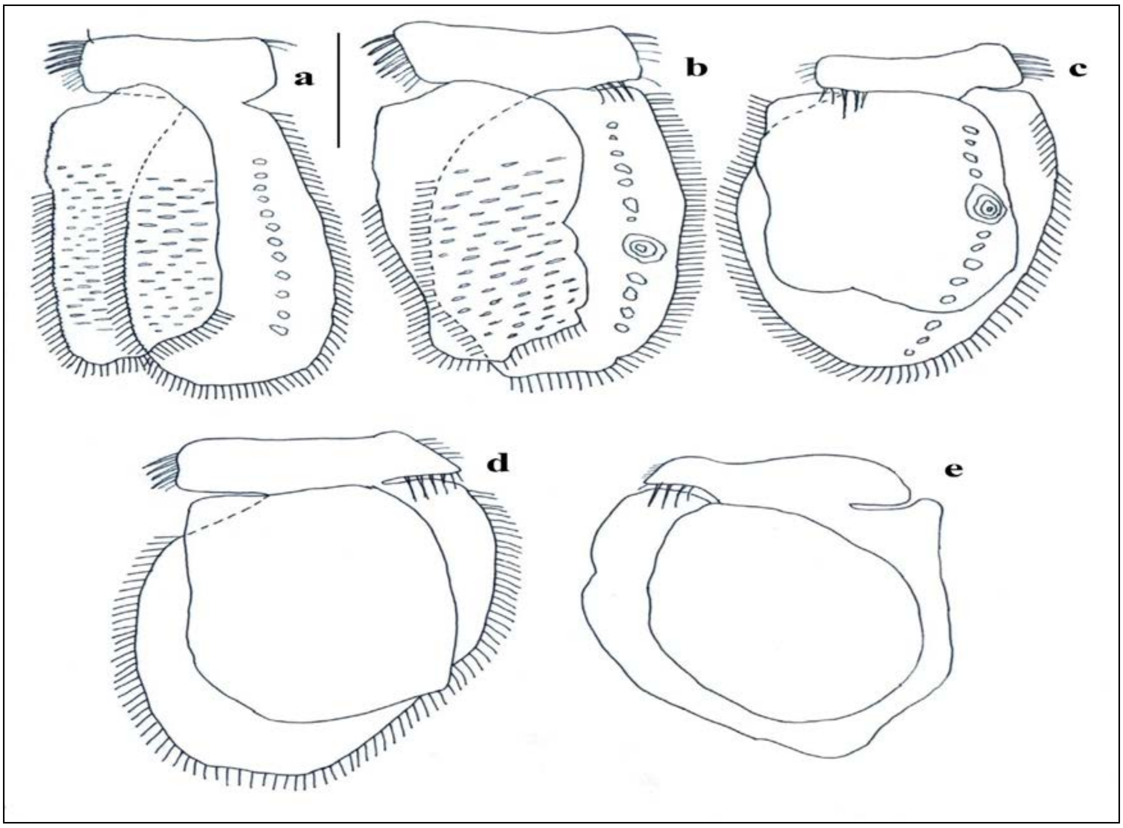

Figure 6: *Rocinela dumerilii* (a-e), Pleopods 1-5 (1.21 mm).

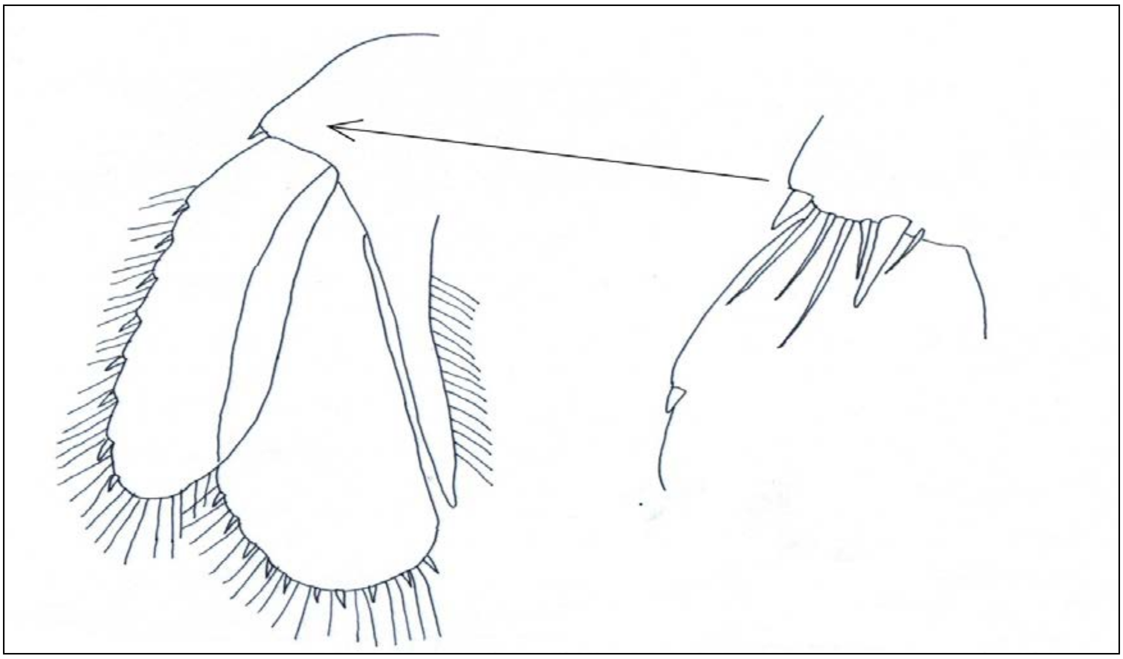

Figure 7: *Rocinela dumerilii*, Uropod and apex of exopod.

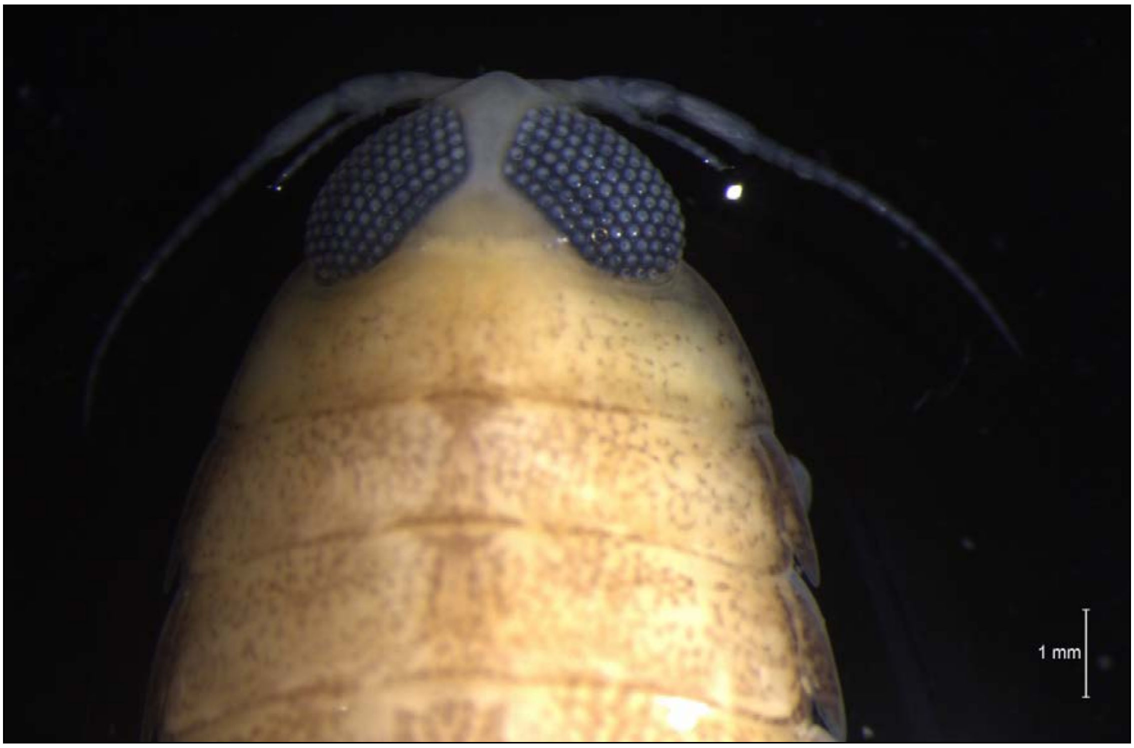

Figure 8: *Rocinela dumerilii*, head.

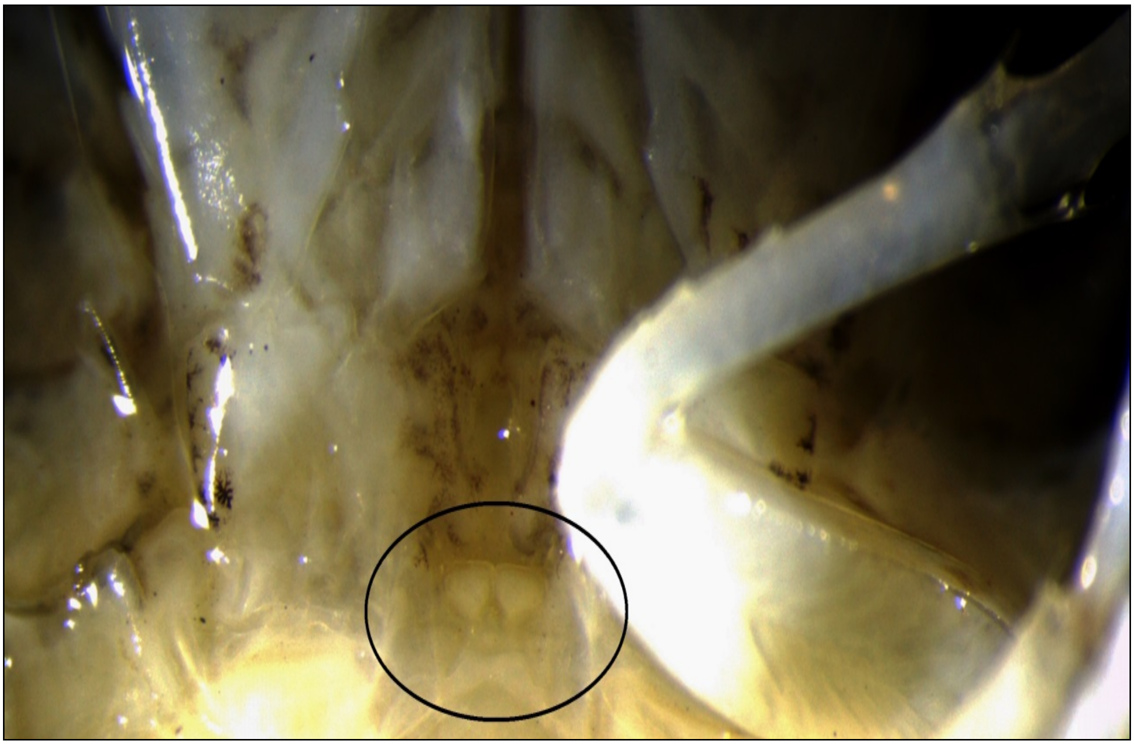

Figure 9: *Rocinela dumerilii*, penes.

Remarks. Fourty-one species belonging to *Rocinela* genus are listed by Worms Editorial Board (2019). The monographs, detailed descriptions, and revision studies concerning *Rocinela* genus have been published mostly on the Australia, New Zealand, and Pacific Ocean (Bruce, 1983; 2009; Brusca, 1983; Brusca and France, 1992).

The historic literature about the species of *Rocinela* in the Mediterranean Sea lack modern or detailed descriptions (Schioedte and Meinert, 1879; Kussakin, 1979; Sars, 1899). Three species belonging to *Rocinela* genus were reported such as *Rocinela ophthalmica* Milne Edwards, 1840, *Rocinela dumerilii* (Lucas, 1849), and *Rocinela danmoniensis* Leach, 1818 from the Mediterranean Sea.

Although there are no detailed descriptions currently available to compare the morphological characters of *R. dumerili* and *R. danmoniensis*, some morphological characters such as the setation on propodus of pereopods and the distance between eyes were compared in this study. *R. dumerilii* species is very closely similar to *R. Danmoniensis* species. The main point of difference is that in *R. danmoniensis* the eyes are closer together and may even touch other (Schiodte and Meinert, 1879; Norman, 1904; Richardson, 1905; Norman and Scott, 1906; Schultz, 1969; Kussakin, 1979; Kırkım et al., 2006). The eyes on *Rocinela* samples in this study are separated by about 9-10% width of head. The propodus of the pereopod two bears four setae in female and male of *R. dumerilii*, but two setae in the propodus of the pereopod one of pullus primus of *R. danmoniensis* according to Schiodte and Meinert (1879). The setation of propodus in this study is consistent with *R. dumerilii*. The morphological extremities of mouth-parts of specimens found in this study have been compared to the findings presented by Monod (1923). The morphology of specimens collected in this study is consistent with the literature concerning *R. dumerilii* (Schiodte and Meinert 1879; Monod, 1923; Kussakin, 1979).

There are several association records between isopods belonging *Rocinela* genus and fish around the world (Novotny and Mahnken, 1971; Brusca and Iverson, 1985; Kensley and Schotte, 1989; Garzón-Ferreira, 1990; Williams et al., 1994; Wing and Moles, 1995; Bunkley-Williams and Williams, 1998; De Lima et al., 2005). Regarding the Mediterranean Sea, there were micropredator reports of *R. danmoniensis* from fish as host. *R. danmoniensis* was reported on Atlantic cod, *Gadus morhua* (Gadidae) (Schiodte and Meinert, 1879) and Blackspot seabream, *Pagellus bogaraveo* (Sparidae) (Hermida et al., 2013). Sars (1899) mentioned that it is more generally found clinging to the skin of fish of various kinds, for instance the common cod, the haddock, the ling, etc. Stephensen (1948) indicated the occurrence of its parasitism on Gadidae such as cod, haddock and lange.

There were some reports of *Rocinela dumerilii* surviving as free-living organisms and from the digested stomach content of some marine organisms. Bedini et al. (2015) reported this species among macroinvertebrate assemblages within a *Posidonia oceanica* meadow. Sampaio et al. (2016) recorded it at 48 meters depth of the Portuguese continental shelf. Alves et al. (2006) recorded it in stomach contents of *Sepia officinalis* Linnaeus, 1758 (Mollusca, Cephalopoda) off the south coast of Portugal, while this species was also reported among the food of grey seals, *Halichoerus grypus* (Fabricius, 1791) (Chordata, Mammalia) from the Isle of Man by Duncan (1956), and as food of the Almaco Jack, *Seriola rivoliana* Valenciennes, 1833 (Chordata, Actinopterygii) in Tunisian marine waters by Mansour et al. (2011).

R. dumerilii was collected on the *Trachurus trachurus* body in this study. *Trachurus trachurus* (Linnaeus, 1758) (Perciformes; Carangidae) is pelagic-neritic and oceanodromus fish with commercial value. It is one of the most important pelagic fish of purse seine and trawling fishery (Froese and Pauly, 2019). The total amount of european hake has been decreasing about 22.200 tones in 2000 to 12.985 tones for 2017 in Turkey (TUIK, 2018).

There is no report regarding micropredations of *R. dumerilii* on fish or other marine organisms according to the available literature. When the interrelationships between members of Carangidae as host and Aegidae as micropredator were examined, the occurrence of some records in the literature is supportive of our finding micropredator behaviour of *R. dumerilii* being also aegid on the atlantic horse mackerel in this study. Bruce (2009) found *Aegapheles alazon* species from the yellowtail horse mackerel, *Trachurus novaezelandiae* Richardson, 1843, belonging to Carangidae family in New Zealand. *R. signata* was reported on *Caranx crysos* (Mitchill, 1815) (Carangidae) and *Oligoplites saliens* (Bloch, 1793) (Carangidae) from Bahia by Carvalho-Souza et al. (2009), while it was reported on *Chloroscombrus chrysurus* (Linnaeus, 1766) (Carangidae) from Rio Grande do Norte by Lima et al. (2011); on *Caranx* sp. from Jamaica; Carrie Bow Cay and Blue Ground Range, in Belize by Kensley and Schotte (1989).

Mansour et al. (2011) found that *Rocinela dumerilii* from the stomach content of almaco jack, *Seriola rivoliana,* being carangid fish in Tunisian marine waters. Torcu Koç and Erdoğan (2019) and Bayhan et al. (2013) indicated that crustaceans were the dominant food category of atlantic horse mackerel. It is our opinion that Atlantic horse mackerel, being a migratory and carnivorous fish species, may have interacted with these isopods during their feeding activities during migrations.

Stepien and Brusca (1985) reported that fish were attacked by members of demersal crustacean assemblage such as luminent ostracod, *Vargula tsujii*, and the isopod *Cirolana diminuta* during their night diving observations while studying the case of death of adult fish in large cages on the seafloor off of the Southern California coast. They summarized the relationships and interactions between nocturnal migrating zooplankton and fish throughout the world.

Nocturnal migrating zooplankton assemblages consist of crustaceans including copepods, ostracods, amphipods, isopods, mysids, cumaceans, decapod larvae, and shrimps. These zooplankton assemblages pose a predation risk for migrating fish in comparison with non-migrating fish. Most nocturnally-active reef fish feed primarily on these migrating forms (Stepien and Brusca, 1985).

Stepien and Brusca (1985) indicated that ostracods are more attracted to chemicals released by healthy, sexually mature fish in comparison to juvenile fish. The chemicals from fish injured by ostracods may serve to attract amphipods and isopods. They observed that both ostracods and isopods often invaded the gills, entered the body cavity, and consumed the fish' gonads and liver. Stepien and Brusca (1985) also discussed that whether anecdotally reported these attacks occurred on live, dying or already-dead fish in the Pacific Ocean, off the coasts of Japan and the Arctic. This may be a possible reason, needed to be studied, for these attacks as the chemicals released from wounds being on fish after caught in the gill net attract isopods and amphipods. It is implied that the phenomenon about attack behaviour may be common in most coastal areas in the world. This attack behaviour was also observed by Turkish commercial fishermen many times during our research surveys.

Family Cymothoidae Leach, 1814

Elthusa Schioedte and Meinert, 1884

Elthusa sinuata (Koelbel, 1879) (Fig. 8)

Synonyms: *Livoneca mediterranea* Heller, 1868; *Livoneca sinuata* Koelbel, 1879; *Livoneca sinuata* Brian, 1912.

Figure 8: *Elthusa sinuata* (1 mm).

Host: the Fries's goby, *Lesueurigobius friesii*.

Infestation area, gill cavity. Examined fish, 70. Infested fish, five. Prevalence, 7.12%. Mean intensity, one.

Sampling stations: 40°31'N-28°12'E; 40°33'N-27°52'E; 40°33'N-27°41'E; 40°26'N-27°36'E.

Elthusa sinuata (syn. *Livoneca sinuata*) was described on the red bandfish, *Cepola macrophthalma* (syn. *Cepolae rubescentis*) from Sicilia by Koelbel (1879). It was reported from North-West Africa, United Kingdom, Mediterranean and Adriatic seas, Spain, France, Algeria, Tunisia, Italy, Yugoslavia, Montenegro, Turkey (van der Wal et al., 2019).

This parasitic isopod has been collected on hosts from several fish species as *Cepola macrophthalma* (Cepolidae), Pleuronectes sp. (Pleuronectidae), *Raja miraletus* (Rajidae), *Boops boops* (Sparidae), *Gobius* sp. (Gobidae), *Brama brama* (Bramidae), *Lepidopus caudatus* (Trichiuridae), *Trichiurus lepturus* (Trichiuridae), *Raja clavata* (Rajidae), and *Argentina sphyraena* (Argentinidae). It was also recorded from two cephalopod species *Sepiola ligulata* and *Loligo vulgaris* except of fish (Öktener et al., 2018; van der Wal et al., 2019).

Although no comment can be made about the host selectivity of *Elthusa sinuata*, six of the ten parasitized species belong to Perciformes. Most of host species exhibit demersal character and carnivorous feeding behaviour. This parasite is found on the gill cavity of Fries's goby, *Lesueurigobius friesii* in this study. This new host species also exhibits demersal character and carnivore feeding behaviour. The characters of this gobiid are similar to the characters of other hosts. This is consistent with findings in *Gobius* sp. reported by Dollfus and Trilles (1976).

CONCLUSIONS

Members of Aegidae are known for their behavior as micropredators or temporary parasites. Although species of these micropredators from Mediterranean have been reported by several researchers many times, information about the biology, life cycles, and interactions and relationships with other organisms of these micropredators are limited. The aim of this study is to contribute scientific information regarding the aforementioned unknown areas about these micropredators.

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GROWTH PATTERN AND LENGTH-WEIGHT RELATIONSHIP IN *POECILIA RETICULATA* (PETERS) (POECILIIDAE) INHABITING THE DRAINAGE CANAL SYSTEM OF LAGOS METROPOLIS (NIGERIA)

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KEYWORDS: Guppy, inland canal, allometric growth, condition factor.

ABSTRACT

This study investigated the growth pattern and length-weight relationship in *Poecilia reticulata* from the canal ecosystem of Lagos, Nigeria. A total of 2,400 fish specimens were caught, with total length ranging from 1.50 to 5.40 (3.30 ± 0.20) cm and weight ranged between 0.10 and 1.50 (0.63 ± 0.03) g. The length-frequency polygon showed four class intervals: 1.50-2.40 cm (51.29%); 2.50-3.40 cm (45.29%); 3.50-4.40 cm (3.25%); and 4.50-5.40 cm (0.17%). The value of “b” ranged from 1.3428-1.9863 which showed negative allometric growth, while the value of “r” ranged from 0.5 to 0.8. The mean K value was 1.05 ± 0.09 – 1.62 ± 0.15.

ZUSAMMENFFASUNG: Wachstumsmuster und Längen-Gewichts-Beziehung Verhältnis bei *Poecilia reticulata* (Peters) (Poeciliidae) im Entwässerungskanalsystem der Metropole Lagos (Nigeria).

Diese in vorliegender Studie wurde untersuchte das Wachstumsmuster und die das Längen-Gewichts-BeziehungVerhältnis bei *Poecilia reticulata* aus dem Kanalökosystem von Lagos, Nigeria untersucht. Insgesamt wurden 2400 Fischen proben gefangen entnommen, deren Gesamtlänge zwischen 1,50 und 5,40 (3,30 ± 0,20) cm lag und zwischen 0,10 und 1,50 (0,63 ± 0,03) g wog. Das Längen-Frequenz-Polygon zeigte vier Klassenintervalle: 1,50-2,40 cm (51,29%), 2,50-3,40 cm (45,29%), 3,50-4,40 cm (3,25%) und 4,50-5,40 cm (0,17%). Der Wert von “b” lag zwischen 1,3428 und 1,9863, was ein negatives allometrisches Wachstum zeigt, während der Wert von “r” zwischen 0,5 und 0,8 lag. Der mittlere K-Wert lag im Bereich von 1,05 ± 0,09 – 1,62 ± 0,15.

REZUMAT: Modelul de creștere și relația lungime-greutate la *Poecilia reticulata* (Peters) (Poeciliidae) care trăiește în sistemul canalelor de drenaj din metropola Lagos (Nigeria).

În acest studiu, s-a investigat modelul de creștere și relația lungime-greutate la *Poecilia reticulata* din ecosistemul de canale de drenaj din Lagos, Nigeria. Au fost prelevate un număr de 2.400 de pești, lungimea lor totală fiind de 1,50 până la 5,40 (3,30 ± 0,20) cm, iar greutatea lor variind între 0,10 și 1,50 (0,63 ± 0,03) g. Poligonul de lungime-frecvență a prezentat patru intervale de clasă, 1,50-2,40 cm (51,29%), 2,50-3,40 cm (45,29%), 3,50-4,40 cm (3,25%) și 4,50-5,40 cm (0,17%). Valoarea „b” a fost cuprinsă între 1.3428-1.9863, prezentând o creștere alometrică negativă, în timp ce valoarea „r” a fost de 0,5-0,8. Valoarea medie K a variat între 1,05 ± 0,09 – 1,62 ± 0,15.

INTRODUCTION

The studies in length-weight relationship (LWR) of fish play a foremost role in fisheries science and management such as the growth and population dynamics (Okgerman, 2005; Sivashanthini, 2008; Bolarinwa and Popoola, 2013; Adaka et al., 2015; Mohamad Radhi et al., 2018).

Additionally, data on LWR could be used to determine the conversion of growth-in-length equation to growth-in-weight and using the conversion in various fish species stock assessment models (Thulasitha and Sivashanthini, 2012; Silva et al., 2015).

Furthermore, the information can be used in the assessment of biomass from length observations, the condition factor of the fish, and for comparison of life histories of certain fish species between different regions (Thulasitha and Sivashanthini, 2012; Paiboon and Kriangsak, 2015).

Moreover, the LWR could be used for other practical needs, like the assessment and monitoring of environment and water resources management because it explains the functional regime in weight distribution per unit size of an aquatic population (Mendes et al., 2004; Zargar et al., 2012). Hence, the length-weight values computed for different stations could be used for numerous ecological parameters of the respective water bodies (Tsoumani et al., 2006; Torrez et al., 2012). The information governs the dimensional variation exhibited by the inhabiting fish species as part of their adaptations to freshwater habitat (Ayandiran and Fawole, 2014).

Likewise, the condition factor (K) is a quantitative parameter that is used in fisheries biology to evaluate the state of well-being of the fish revealing recent feeding conditions (Gupta et al., 2011; Abd Hamid et al., 2015).

The condition factor (value of K) varies according to influences of physiologic factors and varies according to different stages of the development of fish (Da Costa and Araújo, 2003). It integrates many levels of the organismal processes, including cellular, organ system, and molecular (Da Costa and Araujo, 2003; Azmat et al., 2007). Hence, a decrease in condition factor is regarded as a reflection of reduction in energy reserve because it is positively related to energy level in the liver and muscle (Hasan and Secer, 2003). Also, condition factor quantifies whether a fish population is healthy compared to other populations (Paiboon and Kriangsak, 2015) and as an indicator of environmental quality (Ajibare et al., 2017). Equally, it is related to the reproductive cycle of fish (Abowei, 2010; Omobepade and Ajibare, 2015) and an index of feeding intensity and growth of fish (Abowei et al., 2009; George et al., 2013).

The guppy *Poecilia reticulata* (Peters, 1859), a member of Poeciliidae, is a cosmopolitan fish with a wide geographical distribution in South America and sub-Saharan Africa including Nigeria (Kottelat and Whitten, 1996; Lawal et al., 2012).

It is a small opportunistic benthopelagic non-migratory fish occupying a wide range of aquatic habitats, such as weedy ditches, creeks, and canals (Rodriguez, 1997; Lawal et al., 2012).

They are varied in colours and very attractive which make them a veritable export product of ornamental trade and foreign exchange earner (Kottelat and Whitten, 1996; Allen et al., 2002; FishBase, 2006).

Therefore, the objective of this research was to investigate the LWR and variations in the condition factor among sizes and sexes of guppy *Poecilia reticulata* population in the drainage canal system of Lagos Metropolis, Southwestern Nigeria and to provide data from this study as reference values for FishBase (www.fishbase.org).

MATERIAL AND METHODS

The drainage canals (Figs. 1-3) are excavated at both sides of roads for water passage in Lagos Metropolis, Southwestern Nigeria, the most populated metropolis in Africa.

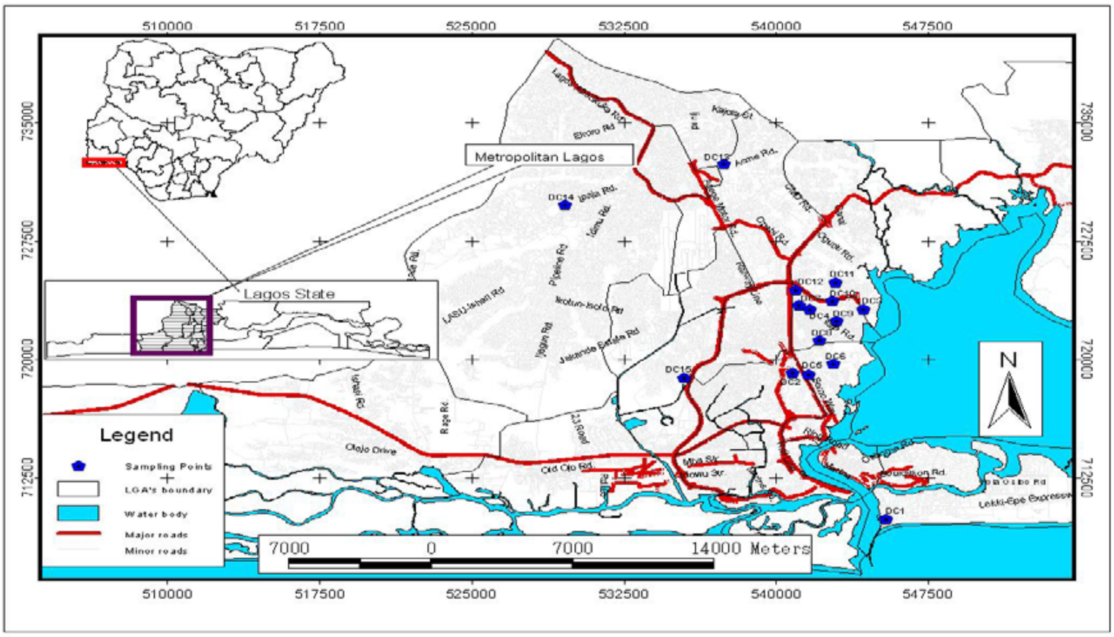

Figure 1: Map of Lagos Metropolis showing sample stations.

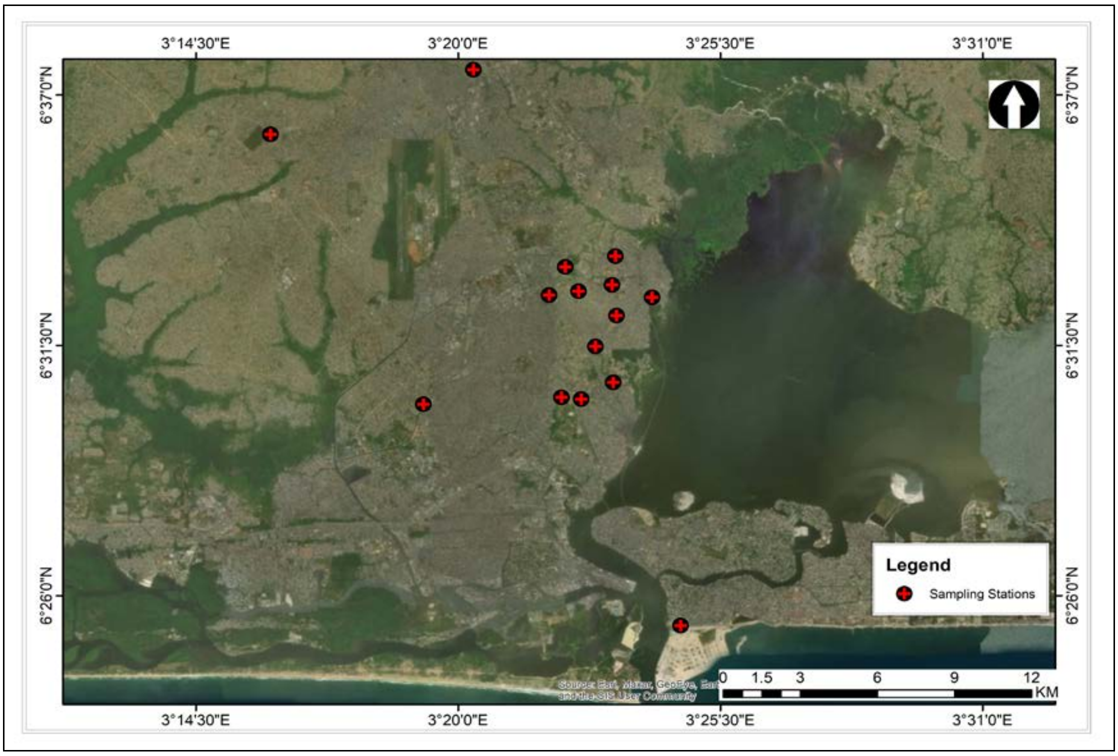

Figure 2: Map of Lagos Metropolis showing sample stations.

These drainage canals lie within longitude 003º22.167 E and 003º24.666 E and stretched between latitude 06º25.343 N and 06º37.557 N (Lawal et al., 2012, 2017).

All these areas are non-tidal and polluted canals which collect surface water run-offs including waste water from residential and industrial buildings, through the numerous creeks in the city and empty into the Lagos Lagoon, and from there far-away into the Atlantic Ocean, (Lawal et al., 2012, 2017).

The drainage canals are shallow with depth ranging from 0.56 m to 1.20 m. The substratum of the canals is made of soft organic mud, mixture of fine and coarse sand, and mixed with decaying organic matter (Lawal et al., 2012, 2017).

Figure 3: The drainage canal, characteristic habitat of *Poecilia reticulata*.

Collection of fish samples and length frequency distribution of *Poecilia reticulata*

Poecilia reticulata individuals (Figs. 4a, b) sampling was done at 15 sampling locations (Figs. 1-2) in the Lagos Metropolis using a GPS (Sportack PRO Marine-Magellan Model) to locate the geographical coordinates of each site. Fish specimens were randomly collected using a long-handled fibre scoop net made of three mm size mesh (Figs. 5a, b). The monthly sampling was done over a two-year period starting from the month of November 2014 to October 2016. The sampled fish were preserved for one week in 10% formalin in situ before transported to laboratory for further investigation at the Ecotoxicology and Fisheries Laboratory, University of Lagos. This preservation did not induced change in fish length and weight.

The total length (TL) was taken from the tip of the snout with mouth closed to the end of the longest caudal fin while the standard length was taken as the distance from the tip of the snout with mouth closed to the base of the caudal peduncle. The measurements were made with a pair of dividers and a meter rule to the nearest tenth of a centimetre. The weight of the fish was taken on a Sartorius top loading balance (Model 1106) to the nearest 10th of a gram.

Figure 4a: *Poecilia reticulata* (male).

Figure 4b: *Poecilia reticulata* (female).

The sex of the fish was determined by visual observation. The male *P. reticulata* has many colourful irregular dark, red, and green markings on the body and fins with the anal fin being modified into gonopodium. The female has rarely a small number of dark spots on the body without colourful markings with normal anal fin (FishBase, 2006).

In this study the length frequency distribution was divided into 1.50-2.40, 2.50-3.40, 3.50-4.40 and 4.50-5.40 cm TL class intervals. Age determination using the length-frequency polygons was based on the expectation that when length-frequency polygons are plotted, there will be clumping of fish of successive ages about successive lengths making separation by age group possible following Petersen's method (Bagenal and Tesch, 1978).

Figure 5a: *Poecilia reticulata* (both sexes) sampled with the scoop net from the drainage canal.

Figure 5b: *Poecilia reticulata* (both sexes) sampled with the scoop net.

Length-weight relationship (LWR) and condition factor (K)

Data was obtained on the length-weight relationship and was tested statistically by the least square regression method. The length-weight relationship of the fish was represented by the equation:

$W = aL^b$ (Bagenal and Tesch, 1978)
Where W = weight (g)
L = standard length (cm)
a = regression constant
b = regression coefficient

The equation was transformed to a linear relationship as follows: $\text{Log } W = \text{Log } a + b \text{ Log } L$

Where b = regression coefficient (slope of the graph)
a = regression constant (intercept of the regression line on the Y axis)

The Fulton's condition factor (K) was determined for the specimens, by sex and size groups. This was based on the following equation:
$K = 100W/L^b$ (Bannister, 1976)
Where W = weight (g)
L = total length (cm)
b = regression coefficient

RESULTS AND DISCUSSION

The total length of the fish sampled throughout the study period ranged from 1.50 to 5.40 cm with a mean value of 3.30 ± 0.20 cm and the standard length ranged from 1.10 cm to 4.30 cm. The weight of the fish ranged from 0.10 to 1.50 g with a mean weight value of 0.63 ± 0.03 g from Lagos Metropolis inland canal ecosystem. The length-frequency distribution for male, female, and combined sex are presented in figures 6-8. The length-frequency polygon showed four size groups: 1.50-2.40 cm (51.29%); 2.50-3.40 cm (45.29%); 3.50-4.40 cm (3.25%); and 4.50-5.40 cm (0.17%) during the research. The cohort interval of 1.50 to 2.40 cm represented the young group, 2.50 to 3.40 cm represented the sub adult group while those from 3.50 to 5.40 cm comprised the adult group. Generally, age of tropical fish is difficult to determine since they experience little seasonal environmental changes and therefore lay down no definite annual rings (Ezenwa and Kusemiju, 1981). For that reason, the age of *P. reticulata* was determined by length frequency polygon which revealed that sizes of fish in this study varied considerably from young to adult stages with different growth rates. Similar reports were documented on several fish species in Nigerian waters and elsewhere. According to Ayandiran and Fawole (2014), a wide range of sizes was exhibited by *Clarias gariepinus* from Oluwa River, Nigeria. Similarly, Abd Hamid et al. (2015) reported different age sizes in fish population from Temengor Reservoir, Malaysia. However, the cohort interval 1.50 to 2.40 cm which is the young fish class interval was the most abundant (51.29%) during the sampling period indicating that the fish bred throughout the year in the canal ecosystem. Furthermore, the combined sex's length-frequency distribution showed a unimodal distribution with modal class at 3.0 representing 1^+ age group of the fish population in the canal ecosystem. Similar report was given for other small, demersal, and non-migratory fish species including *B. soporator* which attained maximum age of one year in Badagry Creek (Lawson et al., 2011). However, food availability and environmental conditions may equally be among the limiting factors to the life-span of this fish.

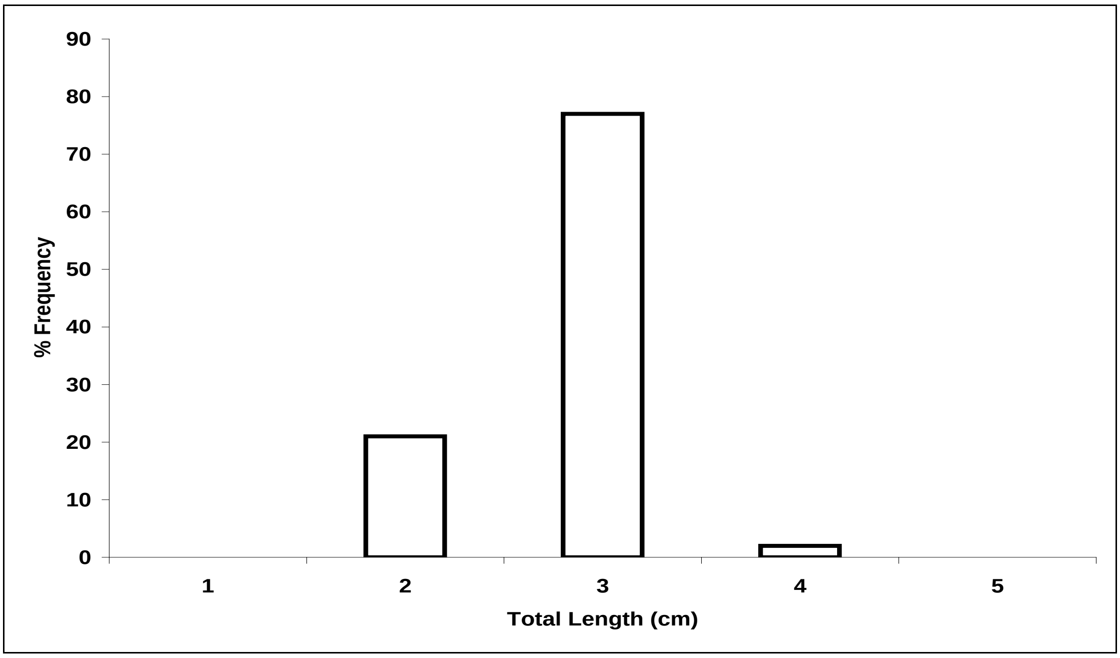

Figure 6: Length-frequency distribution of male *Poecilia reticulata* from study area.

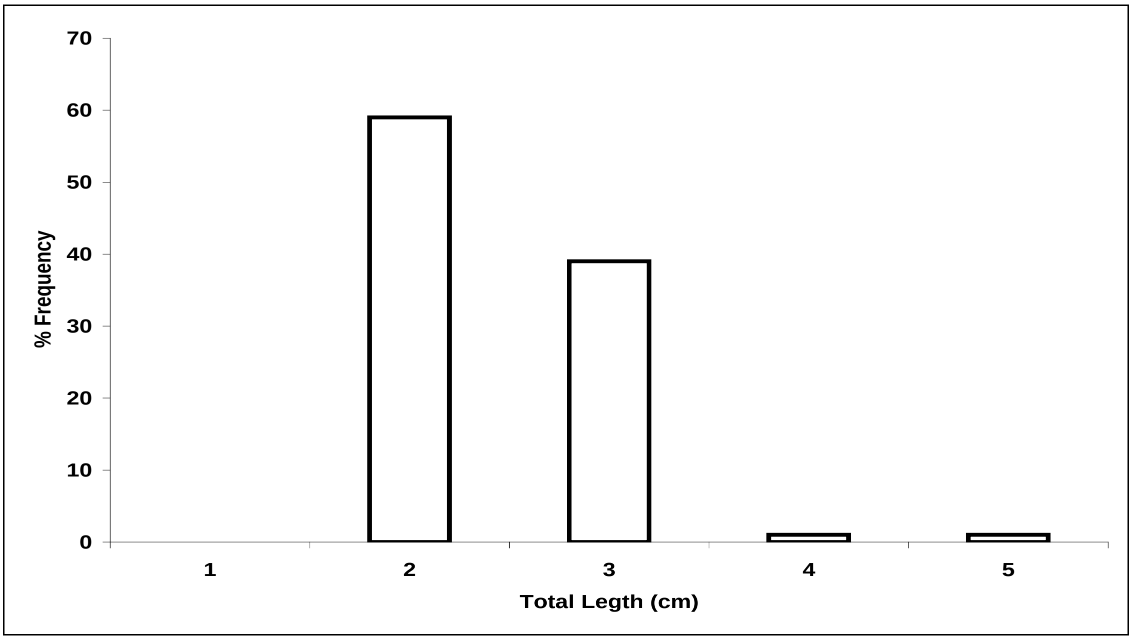

Figure 7: Length-frequency distribution of female *Poecilia reticulata* from study area.

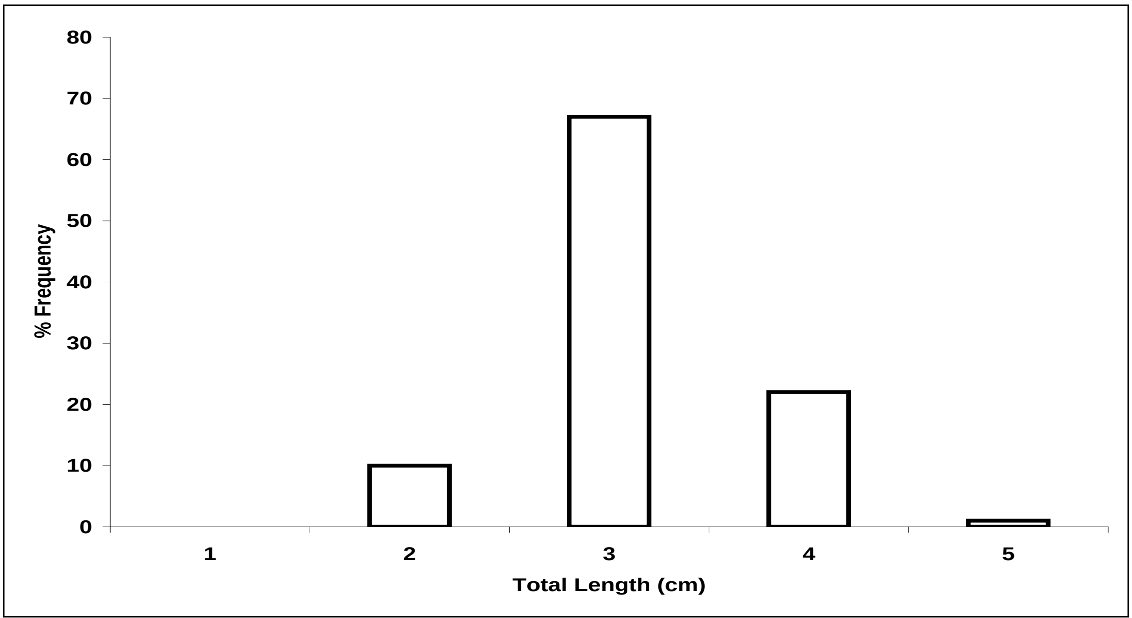

Figure 8: Length-frequency distribution of combined sex of *Poecilia reticulata* from study area.

The relationship between Log length and Log weight measurements of *P. reticulata* are presented in the regression equations shown below:

Male: Log W = – 1.1226 + 1.3428Log L (n = 1052, r = 0.4666)
Female: Log W = – 1.2844 + 1.9863Log L (n = 1348, r = 0.7725)
Combined sex: Log W = – 1.2246 + 1.8136LogL (n = 2400, r = 0.8056)

The regression coefficient (b) larger or smaller than three, shows an allometric growth (Bagenal and Tesch, 1978). When the "b" value is greater than three, it is said to have a positive allometric growth and when "b" value is less than three it shows a negative allometric growth. The values for regression coefficient were 1.34, 1.99, and 1.81 for male, female, and combined sex, respectively in this study. Hence, *P. reticulata* exhibited negative allometric growth in the drainage canal system of Lagos Metropolis (Tab. 1). This implied that the fish may be increasing in length faster than its weight or the weight of the fish increased faster than the cube of its total length (Adeyemi et al., 2009). This result agreed with the submissions of earlier works on numerous fish species in different water bodies (Froese et al., 2011; Obasohan et al., 2012; Ayandiran and Fawole, 2014). Negative allometric growth was also reported for *Parachanna obsura* from Igwu and Itu Rivers wetlands, Nigeria (Bolaji et al., 2011). It is also known that regression coefficient (b) value represents the body form, and it is directly related to the weight of fish affected by ecological factor. These factors include pollution level, habitat, food supply, temperature, spawning conditions, as well as other factors, such as sex, age, and fishing time (Stergiou and Moutopoulos, 2001; Olurin and Aderibigbe, 2006). The environmental conditions (Froese et al., 2011) of guppy could be among factors modifying its growth pattern in the drainage canal, which is a non-tidal, polluted canals, that received water from surface run-off and waste water from both residential and industrial buildings in the metropolis (Lawal et al., 2017). The values for correlation coefficient (r) were 0.5, 0.8, and 0.8 for males, females, and combined sex during the study. These values were close to unity showing high relationship between length and weight in *P reticulata* in the drainage canal system of Lagos Metropolis (Tab. 1). Similar result was recorded for male *Clarias gariepinus* in Oluwa River, Nigeria (Ayandiran and Fawole, 2014). The result of this study could be attributed to the state of sex and age, of the fish species, in addition to the prevailing ecological conditions in the drainage canal.

Table 1: LWR of *P. reticulate* from the drainage canal system of Lagos Metropolis; SE = Standard Error, N = Number of specimen, R = Correlation coefficient, a = Regression constant; b = Regression coefficient, L = Standard length.

Sex	N	R	Equation $W = aL^b$	S.E	a	b	Growth type
Male	1052	0.5	$W = -1.1226L^{1.3428}$	0.120	– 1.1226	1.3428	Allometric (–)
Female	1348	0.8	$W = -1.2844L^{1.9863}$	0.132	– 1.2844	1.9863	Allometric (–)
Combi-ned sex	2400	0.8	$W = -1.2246L^{1.8136}$	0.126	– 1.2246	1.8136	Allometric (–)

The results of the variations in condition factor (K) by size and sex of *P. reticulata* are presented in table 2.

Table 2: Condition factor (K) by sex and size groups of *P. reticulata* from drainage canal system of Lagos Metropolis, Nigeria.

Sex group	N	Size group				K
		Length (cm)	mean ± s.d.	Weight (g)	mean ± s.d.	mean ± s.d
Male	984	1.50 – 2.40	2.11 ± 0.10	0.13 – 0.17	0.15 ± 0.01	1.60 ± 0.14
	68	2.50 – 3.40	2.61 ± 0.12	0.20 – 0.45	0.28 ± 0.02	1.18 ± 0.10
	0					0
	0					0
Female	247	1.50 – 2.40	2.19 ± 0.20	0.13 – 0.17	0.17 ± 0.01	1.62 ± 0.15
	1019	2.50 – 3.40	2.90 ± 0.21	0.20 – 0.45	0.29 ± 0.02	1.19 ± 0.12
	78	3.50 – 4.40	3.72 ± 0.30	0.51 – 0.83	0.54 ± 0.10	1.05 ± 0.09
	4	4.50 – 5.40	4.88 ± 1.00	1.21 – 1.50	1.43 ± 0.13	1.23 ± 0.13
Combined sex	1231	1.50 – 2.40	2.15 ± 0.10	0.13 – 0.17	0.16 ± 0.01	1.61 ± 0.14
	1087	2.50 – 3.40	2.76 ± 0.22	0.20 – 0.45	0.25 ± 0.02	1.19 ± 0.12
	78	3.50 – 4.40	3.72 ± 0.30	0.51 – 0.83	0.54 ± 0.10	1.05 ± 0.09
	4	4.50 – 5.40	4.88 ± 1.00	1.21 – 1.50	1.43 ± 0.13	1.23 ± 0.13

The condition factor (K) which is an index of condition and degree of wellbeing of the fish, varied by size and sex for *P. reticulata*. A fish is said to be in good condition when the value of K is greater or equal to one (Lagler, 1986; Ujjania et al., 2012). The two size groups of male fish had the mean K value ranged between 1.60 ± 0.14 and 1.18 ± 0.10, with the young group size having high K value indicating an active growth process in them while the adult fish could be undergoing reproductive processes. A similar trend was recorded for the three size groups of female fish with the mean K value ranged between 1.62 ± 0.15 and 1.05 ± 0.09. Equally, the mean K value for the combined sex ranged between 1.61 ± 0.14 and 1.05 ± 0.09 for the young and adult size groups respectively. Suggesting that the young fish are actively using the abundance food from organic enrichment of the local substratum for growing (King, 1996), while the other two size groups were either at the stage of gonad development (Maguire and Mace, 1993) or they were making preparation for a new reproductive cycle (Gupta et al., 2011; Lawson et al., 2011). This observation is corroborated by Ujjania et al. (2012) who specified that conditional factors greater or equal to one is good and indicated a good level of feeding, and suitable environmental conditions.

CONCLUSION

This study provides the first basic reference on the growth pattern, length-weight relationship and condition factor for guppy, *P. reticulata* inhabiting the drainage canal system of Lagos Metropolis, Nigeria. The information provided will serve as baseline data for further studies on its biology, ecology, and conservation for a sustainable management of this species in the canals and other water bodies.

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A RECENT TAXONOMIC STUDY OF THE FISH FROM THE JINAM RIVER IN DIMA HASAO BIODIVERSITY HOTSPOT REGION OF ASSAM (INDIA)

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ABSTRACT

The Jinam River habitats inventory revealed the presence of alluvial valley, cascades, riffle-pools, boulders, cobbles, and gravel as types of substrata. The limnological parameters portrayed average values of air and water temperature, turbidity, pH, dissolved oxygen, free carbon di-oxide, total alkalinity, and conductivity.

This recent pioneering study on the fish of the Jinam River in the Dima Hasao District of Assam revealed the presence of 18 species belonging to 15 genera, five families, and three orders, which are reported for the first time through this paper. Worth highlighting is the abundance of *Barilius bendelisis* and *Devario aequipinnatus*, and the fewer numbers of *Chanda nama*, these warranting proper management and conservation of the fish for this river.

RÉSUMÉ: Une récente étude taxonomique des poissons de la rivière Jinam, dans le hotspot de biodiversité de Dima Hasao dans l'État d'Assam (Inde).

L'inventaire des habitats de la rivière Jinam a révélé la présence de vallées alluviales ainsi que de cascades et celle de bassins rapides. Les types de substrats de gravier présents sont constitués par des blocs rocheux et des galets. Les valeurs moyennes des paramètres limnologiques ont permis de représenter les températures de l'air et de l'eau, la turbidité, le pH, l'oxygène dissous, le dioxyde de carbone libre, l'alcalinité, totale et la conductivité.

Cette étude récente et novatrice sur les poissons de la rivièrè Jinam dans le district de Dima Hasao en Assam a révélé la présence de dix-huit espèces appartenant à quinze genres, cinq familles et trois ordres, qui ont été révélées pour la première fois grace à cet article. Il est important de souligner l'abondance de *Barilius bendelisis* et *Devario aequipinnatus*, ainsi que le faible nombre de *Chanda nama*, justifiant ainsi la mise en place d'une gestion et une conservation appropriées des poissons dans cette rivière.

REZUMAT: Un studiu taxonomic recent asupra peştilor râului Jinam din hotspotul de biodiversitate Dima Hasao a regiunii Assam (India).

Inventarierea habitatelor râului Jinam a relevat prezenţa văii aluviale, a cascadelor şi bazinetelor, şi a sectoarelor cu substrat de bolovani, pietre şi pietriş. Valorile medii ale parametrilor limnologici au reprezentat temperatura aerului şi a apei, turbiditatea, pH-ul, oxigenul dizolvat, dioxidul de carbon liber, alcalinitatea totală şi conductivitatea.

Acest recent studiu de pionierat asupra peştilor râului Jinam din districtul Dima Hasao din Assam a dezvăluit prezenţa a 18 specii aparţinând la 15 genuri, cinci familii şi trei ordine, care sunt raportate pentru prima oară prin această lucrare. Demn de subliniat este abundenţa speciilor *Barilius bendelisis* şi *Devario aequipinnatus*, în timp ce specia *Chanda nama* s-a dovedit a fi mai puţin abundentă, astfel garantându-se managementul şi conservarea corespunzătoare a corplui de apă şi a peştilor.

INTRODUCTION

The aquatic biodiversity is under continuously increasing pressure due to various kinds of human-induced impacts and their effects, including effects on fish and their habitats (Degerman et al., 2001; Adom, 2018; Kar, 2019; Shao et al., 2019; Bănăduc et al., 2020; Lacerda et al., 2020).

India is one of the mega biodiversity countries of the World and occupies 9th position in terms of freshwater mega biodiversity (Jayaram, 1981, 1999, 2003, 2010). In India, there are approximately 2,500 species of fish, of which, around 930 live in freshwater (FW) and around 1,570 are marine (Jayaram, 1981, 1999, 2003, 2010; Kar, 2000, 2005, 2007, 2013). This bewildering ichthyodiversity of this region has been attracting many ichthyologists both from India and abroad.

Concomitantly, the North-Eastern (NE) region of Indian territory has been identified as a “Hotspot” of Biodiversity by the World Conservation Monitoring Centre (Talwar and Jhingran, 1991; Kar, 2007, 2013).

The hills and the undulating valleys of this region give rise to a large number of torrential hill streams, which lead to big rivers and finally become part of the Ganga-Brahmaputra-Barak-Chindwin-Kolodyne-Gomati-Meghna hydrographical system (Kar, 2005, 2007; Jayaram, 2010).

Assam region is rich in valuable aquatic and semi-aquatic habitats, which are located in wildlife sanctuaries, national parks and even in Biosphere reserve areas, some of them are Ramsar sites (Kar, 2019).

The River Jinam originates in the hills of the Dima Hasao District in Assam and after receiving a number of small streams, notably Tuikoi and others, it joins the river Jiri near Jirighat along Assam-Manipur border.

The icthyofauna of NE region of India has elements of the Indo-gangetic region and to some extent, of the Myanmarese and South-Chinese regions (Wikramanayake and Moyle, 1989). The tropical Asian ichthyofauna constitutes a substantial part of the total lotic fish community. The Indian Peninsula supports 930 species of native freshwater fish which belong to 87 families (Jayaram, 2010) and the NE India represents a significant proportion of the Indian fish biodiversity (Kar and Sen, 2007).

Ghosh and Lipton (1982) reported 172 species of fish with reference to their economic importance; while Sen (1985) reported 187 species from Assam and its environs. Sinha (1994) compiled a list of 230 species of fish from NE India. Nevertheless, Nath and Dey (1997) recorded 131 species of fish from the drainages in Arunachal Pradesh alone. Sen (2000) comprehensively compiled a list of 267 species of fish from NE India. Further, according to Sen (2000), of the 806 species of fish inhabiting the freshwaters of India (Sinha, 1994), the NE region of India is represented by 267 species belonging to 114 genera under 38 families and 10 orders. This is around 33.13% of the total Indian freshwater fish species.

Of the 267 species, Cypriniformes dominates around 145 species followed by Siluriformes (72), Perciformes (31), Clupeiformes (seven), Anguilliformes (three), Cyprinodontiformes (three), Osteoglossiformes (two), Synbranchiformes (two, Syngnathiformes (one) and Tetraodontiformes (one). Kar (2003) reported the occurrence of 133 species of fish through a pilot survey conducted in 19 rivers spread in Barak drainage (Assam), Mizoram and Tripura. Kar (2003) reported the occurrence of 103 species of fish through an extensive survey conducted in six principal rivers in Barak Valley (Assam), Mizoram and Tripura. Kar (2005) and Kar and Sen (2007) have done a detailed study on the biodiversity of fish in NE India with particular reference to Barak drainage, Mizoram and Tripura.

MATERIAL AND METHODS

Fish samples were collected through experimental fishing using caste nets (diameters of 3.7 m and 1.0 m), gill nets (vertical height 1.0 m – 1.5 m; length 100 m – 150 m), drag nets (vertical height 2.0 m), triangular scoop nets (vertical height 1.0 m), cage traps (length 0.90 m, breadth 0.60 m, height 1.0 m), and basket traps (length 0.80 m, breadth 0.65 m, height 1.10 m). A camouflaging technique was also used to catch the fish. Fish were first preserved in concentrated formaldehyde in the field and then in a 10% formalin. Fish have been identified after standard literature of Day (1878, 1885, 1889), Shaw and Shebbeare (1937), Misra (1959, 1976), Menon (1974, 1999), McClelland (1839), Talwar and Jhingran (1991), and Jayaram (1981, 1999, 2003, 2010).

The arrangement of classification, which is followed here, is of Greenwood et a1. (1966) and Jayaram (1981, 1999, 2003, 2010). In the specific synonymies, only original reference of the species with its type locality and Jayaram's reference (1981) are given in the handbook of freshwater fish of India, Pakistan, Bangladesh, Burma, and Sri Lanka are written.

RESULTS AND DISCUSSION

River Jinam is a characteristic hill stream situated in the Dima Hasao District of Assam area (25º08'27"N and 93º16'32"E; altitude 658 m m.s.l.), which is a biodiversity very rich hotspot.

Study of habitat inventory of the Jinam River revealed a regime type reach of alluvial valley segment, cascade and riffle-pool types of microhabitat in different segments of the river, boulder and cobble, gravel types of substratum, bottom-free big boulders, undercut banks serving as fish cover; overhanging vegetation consisting mostly of shrubs; riparian vegetation represented mainly by trees and shrubs, and riparian land use pattern consists mainly of human habitation. Average values of bankfull, channel and wetted widths, depths, and current velocity, revealed values of 45 m, 35 m, 20 m, 2.2 m, 1.6 m, 0.52 m and five cm/second respectively. Similarly, the average values of limnological parameters portrayed values of water temperature (ºC), air temperature (ºC), turbidity (NTU), pH, dissolved oxygen (DO), free carbon di-oxide (FCO_2); total alkalinity (TA); and conductivity as 18.8, 19.6, 3.03, 6.47, 5.99, 1.31, 59.66, and 121 respectively.

A total of 18 species of fish have been sampled and recorded for the first time from a pioneering and reconnaissance ichthyological study in the River Jinam in Dima Hasao District of Assam.

These include the Cypriniformes: *Barilius bendelisis* (Hamilton, 1807), *Barilius barila* (Hamilton, 1822), *Opsarius shacra* (Hamilton, 1822), *Opsarius dimorphicus* (Tilak and Hussain, 1990), *Devario aequipinnatus* (McClelland, 1839), *Danio dangila* (Hamilton, 1822), *Esomus danrica* (Hamilton, 1822), *Amblypharyngodon mola* (Hamilton, 1822), *Puntius sophore* (Hamilton, 1822), *Pethia conchonius* (Hamilton, 1822), *Neolissochilus hexagonolepis* (McClelland, 1839), *Neolissochilus hexastichus* (McClelland, 1839), *Garra kempi* (Hora, 1921) and *Lepidocephalichthys guntea* (Hamilton, 1822); Siluriformes: *Mystus bleekeri* (Day, 1877); and Perciformes: *Parambassis ranga* (Hamilton, 1822), *Chanda nama* Hamilton, 1822 and *Trichogaster lalius* (Hamilton, 1822).

The morphometric and meristic features of each species are represented in tables 1a-c.

The characteristic features of the genera, key to species level identification, their distribution and conservation status are discussed below.

Class Actinopterygii
Order Cypriniformes
Family Cyprinidae

Genus: *Barilius* Hamilton, 1822

Diagnostic characters: Body moderately elongate, compressed. Abdomen rounded. Head sharply pointed; may be with "peral organs" and tubercles. Mouth anterior or obliquely directed upwards. Eyes large, superior, in the anterior half of the head, not visible from below ventral surface. Upper jaw longer than lower. Characteristic muscular pads present in front of the bases of the pectoral fins. Dorsal fin inserted opposite to inter-space between pelvic and anal fins, nearer to caudal fin base than to tip of snout. Caudal fin forked. Scales moderate. Lateral line concave. Body usually covered with vertical bands.

1. ***Barilius bendelisis*** (Hamilton, 1807): 18 individuals, River Jinam, Dima Hasao District, Assam, 25º08'27"N and 93º16'32"E, altitude 658 m; 9-12.11.2014, 25.01.2017 (collectors Kar and Party). Anal fin short with six to eight rays, each scale usually has a black spot on it. The range of observations is given in table 1a.
Distribution: throughout India including River Jinam in Dima Hasao District in Assam (first report), Bangladesh, Myanmar, Nepal, Pakistan, Sri Lanka, and Thailand. IUCN Status: Least Concern (LC).

2. ***Barilius barila*** (Hamilton, 1822): three individuals, River Jinam, Dima Hasao District, Assam, 25º08'27"N and 93º16'32" E, altitude 658 m; 11.11.2014 (collectors Kar and Party). Body with 14 or 15 vertical bars, short extending from back to lateral line. The range of observations are given in table 1c.
Distribution: Throughout NE India including River Jinam in Dima Hasao District (first report). Bihar, Delhi, Jammu and Kashmir, Madhya Pradesh, Mysore, Orrisa, Rajasthan, Uttar Pradesh, West Bengal, Bangladesh, Myanmar and Nepal. IUCN Status: Least Concern (LC).

Genus: *Opsarius* McClelland, 1839

Diagnostic characters: Body moderately elongate, compressed. Abdomen rounded. Head sharply pointed; may be with "peral organs" and tubercles. Mouth anterior or obliquely directed upwards. Eyes large, superior, in the anterior half of the head, not visible from below ventral surface. Upper jaw longer than lower. Characteristic muscular pads present in front of the bases of the pectoral fins. Dorsal fin inserted opposite to inter-space between pelvic and anal fins, nearer to caudal fin base than to tip of snout. Caudal fin forked. Scales moderate. Lateral line concave, body usually covered with vertical bands.

3. ***Opsarius shacra*** (Hamilton, 1822): two individuals, River Jinam, Dima Hasao District, Assam, 25º08'27"N and 93º16'32" E, altitude 658 m; 11.11.2014 (collectors Kar and Party). Body with 12 vertical bars. The range of observations is given in table 1a.
Distribution: Arunachal Pradesh, Assam including River Jinam in Dima Hasao District in Assam (first report), Manipur, Mizoram, Nagaland, Tripura, Ganga, Yamuna and Brahmaputra river system, Bangladesh, Nepal. IUCN Status: Least Concern (LC).

4. ***Opsarius dimorphicus*** (Tilak and Hussain, 1990): four individuals, River Jinam, Dima Hasao District, Assam, 25º08'27"N and 93º16'32" E, altitude 658 m; 11.11.2014 (collectors Kar and Party). Body with four irregular rows of spots. The range of observations is given in table 1c.
Distribution: Tripura, Uttar Pradesh, Assam including River Jinam in Dima Hasao District (first report). The species is endemic to India. IUCN Status: Vulnerable (VU).

Genus *Devario* Heckel, 1843

Diagnostic characters: Mainly differentiated from *Danio* by a short, wide pre-maxillary ascending process with a minute apophysis connecting the kinethmoid; a short maxillary barbell. Infraorbital five, absent or slightly reduced.

5. ***Devario aequipinnatus*** (McClelland, 1839): two individuals, River Jinam, Dima Hasao District, Assam, 25º08'27"N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Lateral line complete with 34-37 scales. Dorsal fin with 8-11 branched rays. Well-marked lateral bands along sides of the body with thinner golden bands above and below it. The range of observations is given in table 1a.
Distribution: Throughout India. First report from River Jinam in Dima Hasao District of Assam, Bangladesh, Bhutan, Myanmar, Nepal, Pakistan, Sri Lanka, and Thailand. IUCN Status: Least Concern (LC).

Genus *Danio* Hamilton, 1822

Diagnostic characters: Body elongate, compressed, abdomen rounded, head moderate, blunt, snout obtuse, mouth anterior; cleft of mouth shallow and protractile, directed obliquely upwards. The end of lower jaw in line with dorsal profile and with a symphysial knob. Eyes large, centrally placed, not visible from below ventral surface. Lower jaw prominent with a knob at the symphysis. One or two pairs of barbells, rudimentary or none. Dorsal fin inserted opposite inter-space between anal and pelvic fins, nearer to caudal fin base than to tip of snout, with 10 or 19 rays. Anal fin with nine to 14 rays. Caudal fin emarginated, lunate or forked. Scales moderate. Lateral line concave, complete with 32 to 42 scales. A stripe on the anal fin rays. An anterior lateral extension ventral on the dentary. Two or more pigmented stripes on the caudal fin rays.

6. ***Danio dangila*** (Hamilton, 1822): four individuals, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Barbells well developed, longest in the species. The range of observations is given in table 1c.
Distribution: Throughout NE India including River Jinam in Dima Hasao District in Assam (first report), Bihar, Eastern Himalaya, Madhya Pradesh, Uttar Pradesh, and West Bengal; Bangladesh, Bhutan, Myanmar, and Nepal. IUCN Status: Least Concern (LC).

Genus: *Esomus* Swainson, 1839

Diagnostic characters: Body elongate, strongly compressed. Abdomen rounded. Head and snout small, blunt. Mouth small, obliquely directed upwards without a symphysial knob. Two pairs of barbells; maxillary pair very long and extends up to anal fin. Dorsal fin inserted in the inter-space between pelvic and anal fins; nearer to anal fin than to pelvic fins, with six branched rays and no spine. Anal fin with five branched rays. Caudal fin forked. Lateral line may be present with 27-34 scales or absent.

7. ***Esomus danrica*** (Hamilton, 1822): three individuals, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Body with broad lateral bands on sides, 14 scales around caudal peduncle. The range of observations is given in table 1c.
Distribution: Throughout India, including River Jinam in Dima Hasao District in Assam (first report); Afghanistan, Bangladesh; Myanmar; Nepal; Pakistan, Sri Lanka, Thailand, and South Vietnam. IUCN Status: Least Concern (LC).

Genus: *Amblypharyngodon* Bleeker, 1860

Diagnostic characters: Body moderately long, sub-cylindrical. Abdomen round. Head much compressed. Snout obtusely rounded. Mouth wide, antero-lateral and not protractile. Eyes centrally-placed and large; they are not visible from below ventral surface. Upper lip absent. Lower lip with a short labial fold. Lower jaw prominent with a thin sharp edge and a symphysial knob which fits into the upper jaw. Barbells absent. Dorsal fin inserted little behind insertion of pelvic fins. Anal fin short. Caudal fin forked. Scales minute.

8. ***Amblypharyngodon mola*** (Hamilton, 1822): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Lateral line incomplete with 65-91 scales. A silvery lateral band with dark markings on dorsal, anal and caudal fins present. The observations are given in table 1a.
Distribution: Throughout India including River Jinam in Dima Hasao District, Assam (first report); Afghanistan, Bangladesh, Myanmar, Nepal, Pakistan, and Sri Lanka. IUCN Status: Least Concern (LC).

Genus: *Puntius* Hamilton, 1822

Diagnostic characters: Body short to moderately long, deep, compressed. Abdomen round. Head short. Snout obtuse, conical or pointed; sometimes, may be with tubercles. Mouth arched, anterior or inferior. Upper jaw may be protractile. Eyes moderate to large, dorso-lateral; they are not visible from below ventral surface. Lips thin, cover the jaws; without any horny covering. Jaws simple without any tubercle at the symphysis. Barbells four, two or may be absent. Dorsal fin short inserted nearly opposite to pelvic fins. Anal fin short. Caudal fin forked. Scales small, moderate or large.

9. ***Puntius sophore*** (Hamilton, 1822): one individual, River Jinam, Dima Hasao district, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Presence of a black spot on dorsal fin and caudal peduncle. The observations are given in table 1b.
Distribution: Throughout India including River Jinam in Dima Hasao District, Assam (first report); Afghanistan, Bangladesh, Bhutan, China, Myanmar, Nepal, Pakistan, and Sri Lanka. IUCN Status: Least Concern (LC).

Genus: *Pethia* Pethiyagoda, Meegaskumbura and Maduwage, 2012

Diagnostic characters: Body short to moderately long, deep, compressed. Abdomen rounded. Head short. Snout obtuse, conical or pointed; sometimes, may be with tubercles. Mouth arched, anterior or inferior. Upper jaw may be protractile. Eyes moderate to large, dorso-lateral; they are not visible from below ventral surface. Lips thin, cover the jaws; without any horny covering. Jaws simple without any tubercle at the symphysis. Barbells four, two or may be absent. Dorsal fin short inserted nearly opposite to pelvic fins. Last unbranched dorsal fin ray stiff and serrated. Anal fin short. Black spot on caudal peduncle. Caudal fin forked. Scales small, moderate or large.

10. ***Pethia conchonius*** (Hamilton, 1822): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 11.11.2014 (collectors Kar and Party). Presence of a black blotch on caudal peduncle. Lateral line incomplete with 24-26 scales. The observations are given in table 1b.
Distribution: Throughout NE India including River Jinam in Dima Hasao District, Assam (first report), West Bengal, Bihar, Uttar Pradesh, Punjab Maharashtra, Orissa, Eastern and Western Himalaya; Afghanistan, Bangladesh, Myanmar, Nepal, Pakistan, and Sri Lanka. IUCN Status: Least Concern (LC).

Genus: *Neolissochilus* Rainboth, 1985

Diagnostic characters: Body deep anteriorly. Trunk and peduncle smoothly tapering from anterior end to posterior end. Abdomen rounded. Head broad. Snout blunt. Mouth oblique, near terminal to horizontal or inferior. Species with horizontal mouth often have the lobe of snout overhanging the upper lip. Mouth smoothly rounded when the lower jaw is blunt. Eyes in upper half of head; visible both from dorsal and ventral surfaces. Lips thick. Cheeks with many tubercles. Labial fold interrupted. Scales large and heavy.

11. ***Neolissochilus hexagonolepis*** (McClelland, 1839): two individuals, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 10.11.2014 (collectors Kar and Party). Mouth nearly truncates. Edge of lower jaw sharp. The range of observations is given in table 1a.

Distribution: Throughout NE India including River Jinam in Dima Hasao District in Assam (first report), Northern India, Darjeeling, Eastern Himalaya, South and South-Eastern Asia. IUCN Status: Near Threatened (NT).

12. ***Neolissochilus hexastichus*** (McClelland, 1839): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 12.11.2014 (collectors Kar and Party). Mouth rounded smoothly, edge of lower jaw blunt. Dorsal fin nearer to tip of snout than to caudal fin base. The observations are given in table 1a.

Distribution: Arunachal Pradesh, Assam including River Jinam, Dima Hasao District in Assam (first report); Meghalaya, Mizoram, Nagaland, Rivers from Kashmir to Sikkim, Myanmar. IUCN Status: Near Threatened (NT).

Genus: *Garra* Hamilton, 1822

Diagnostic characters: Body short, sub-cylindrical. Ventral surface flat. Head little depressed anteriorly. Snout blunt; smooth or with pores; with or without a deep transverse groove-like depression. Mouth inferior, transverse, semi-circular. Eyes small; in the posterior half of the head; lateral; not visible from below ventral surface. Lips thick and fleshy. Upper and lower lips are continuous without any lateral lobes. A proboscis may or may not be present. A suctorial disc of semi-cartilaginous pad present on the chin. Scales moderate.

13. ***Garra kempi*** (Hora, 1921): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Vent situated almost midway between origin of anal and pelvic fins. Lateral line with 38-40 scales. A W-shaped band on caudal fin. The observations are given in table 1b.

Distribution: Arunachal Pradesh, Assam including River Jinam in Dima Hasao District (first report); Eastern Himalayas, Manipur, and Nepal. IUCN Status: Least Concern (LC).

Family: Cobitidae

Genus: *Lepidocephalichthys* Bleeker, 1863.

Diagnostic characters: Body long with a laterally compressed caudal peduncle. Abdomen round. Head short, conical. Snout blunt. Mouth inferior, narrow, slightly arched. Eyes small, superior, covered with transparent skin, in anterior part of head; not visible from below ventral surface of head. Lips thick, fleshy, continuous at angle of mouth; lower lip interrupted in the middle. Presence of a large erectile bifid sub-orbital spine below or in front of the eyes. Scales small covering the lateral and ventral sides of the head and body.

14. ***Lepidocephalichthys guntea*** (Hamilton, 1822): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Body moderately long. Mental lobe well developed and produced into one or two projections. The observations are given in table 1b.
Distribution: Throughout India including River Jinam in Dima Hasao District, Assam (first report); Bangladesh, Myanmar, Nepal, Pakistan, and Thailand. IUCN Status: Least Concern (LC).

Order: Siluriformes

Family: Bagridae

Genus: *Mystus* Scopoli, 1777

Diagnostic characters: Body short or moderately elongated. Head short, flattened. Snout obtuse or rounded. Mouth sub-terminal, transverse. Eyes anteriorly situated, moderately large. Teeth numerous. Upper surface of head mostly smooth with one or two median longitudinal grooves of varying length. Occipital process long or short, situated superficially concealed under skin. Four pairs of barbells; one each of maxillary, nasal and two mandibular, two dorsal fins; an anterior rayed dorsal with seven or eight rays and a spine; a posterior smooth low adipose fin of varying lengths. Pectoral fins with seven to 11 rays and a strong spine serrated along the inner edge. Pelvic fins with six rays. Anal fin with nine to 14 rays. Caudal fin forked, bilobed with unequal lobes; lobes may be rounded, pointed or prolonged into filamentous extensions. Lateral line simple, complete.

15. ***Mystus bleekeri*** (Day, 1877): one individual, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Maxillary barbells reach base of anal fin. Three broad conspicuous dark bands separated by two pale lines on each side of lateral line. The observations are given in table 1c.
Distribution: North India and NE India including River Jinam, Dima Hasao District, Assam (first report), Mahanadi headwaters, Baroda, Godavari, Kerala, Maharashtra, Tamil Nadu, Bangladesh, Bhutan, Indonesia, Myanmar, Malaya, Nepal, Pakistan, Sumatra, and Thailand.
IUCN Status: Least Concern (LC).

Order: Perciformes

Family: Ambassidae

Genus: *Parambassis* Bleeker, 1874

Diagnostic characters: Body elongate, compressed. Abdomen round. Head short, compressed. Snout pointed. Mouth large; gape oblique; extending to anterior border of orbit. Eyes large, superior, not visible from below ventral surface of head. Jaws straight or only slightly upturned. Supra-orbital ridge smooth or serrated, with one or two spines posteriorly. Pre-orbit serrated on both ridge and edge. Sub-orbit also serrated. Cheek with four to seven transverse scale rows.

16. ***Parambassis ranga*** (Hamilton, 1822): three individuals, River Jinam, Dima Hasao District, Assam, 25º08'27" N and 93º16'32" E, altitude 658 m; 10-12.11.2014 (collectors Kar and Party). Body transparent with a silvery broad lateral stripe on sides. The range of observations is given in table 1b.
Distribution: Throughout India including River Jinam in Dima Hasao District, Assam (first report); Bangladesh; Malaysia, Mayanmar, Nepal, Pakistan, Siam, and Thailand. IUCN Status: Least Concern (LC).

Genus: *Chanda* Hamilton, 1822

Diagnostic characters: Body ovate, deep compressed. Abdomen rounded. Head short, compressed with sharp snout. Mouth wide, protractile; extended up to border of orbit or slightly beyond. Eyes large, superior. Pre-orbital edge with four serrae. Lower jaw strongly projecting. Lower limb of pre-opercle with a double-serrated edge. Opercula without a prominent spine. Two dorsal fins; 1st with seven spines and 2nd with 15-17 rays; the two dorsal fins continuous. A forwardly directed recumbent spine present in the dorsal fin. Anal fin with three spines and 17 rays. Caudal fin forked. Body with cycloid scales. Laleral line complete with 125 scales.

17. ***Chanda nama*** Hamilton, 1822: one individual, River Jinam, Dima Hasao District, Assam, 25º08’27” N and 93º16’32” E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Three prominent canine teeth on either side of lower jaw. The observations are given in table 1c.

Distribution: Throughout India including River Jinam in Dima Hasao District, Assam (first report); Bangladesh, Myanmar, Nepal, and Pakistan. IUCN Status: Least Concern (LC).

Family: Osphronemidae

Genus: *Trichogaster* Bloch and Schneider, 1801

Diagnostic characters: Body elevated, compressed. Head moderate, compressed. Snout blunt. Mouth upturned, terminal, cleft small. Eyes large, lateral, in middle of head, not visible from below ventral surface of head. Jaws a little protractile. Ventral border of pre-opercle usually serrated. Number of spines in dorsal and anal fins variable.

18. ***Trichogaster lalius*** (Hamilton, 1822): one individuals, River Jinam, Dima Hasao District, Assam, 25º08’27” N and 93º16’32” E, altitude 658 m; 25.01.2017 (collectors Kar and Party). Caudal fin wedge-shaped. Soft part of dorsal and anal fins not produced; but, rounded. Body with scarlet and light blue oblique bands. The observations are given in table 1b.

Distribution: Assam including River Jinam in Dima Hasao District (first report), Manipur, Nagaland, Ganga, and Jamuna River system; Bangladesh, Borneo, Myanmar, Nepal, Pakistan, and Singapore. IUCN Status: Least Concern (LC).

CONCLUSIONS

The present study is the first reporting of the fish of the river Jinam, in the Dima Hasao District of Assam within the biodiversity hotspot region of the Eastern Himalayas.

The study revealed the occurrence of rheo-philic fish species notably, *Garra kempi* (Hora, 1921), *Neolissochilus hexagonolepis, Neolissochilus hexastichus, Barilius bendelisis, Barilius barila, Opsarius shacra, Opsarius dimorphicus*. Incidentally, occurrence of *Opsarius dimorphicus* in river Jinam is interesting.

Of lesser abundance, some of the hill stream fish, notably *Garra kempi, Neolissochilus hexagonolepis*, and *Neolissochilus hexastichus*, a declaration of aquatic sanctuary for some stretches of the river Jinam, particularly those having cascade and riffle type microhabitat with boulders, cobbles and gravels as substrata, is hereby strongly recommended.

Table 1a: Morphometric and meristic counts of: *Barilius bendelisis*, *Opsarius shacra*, *Neolissochilus hexagonolepis*, *N. hexastichus*, *Devario aequipinnatus*, *Amblypharyngodon mola*.

	B. bend. (n = 18)	*O. shac.* (n = 2)	*N. hexag.* (n = 2)	*N. hexas.* (n = 1)	*D. aequ.* (n = 2)	*A. mola* (n = 1)
Morphometrics						
Weight (gm)	5.0-55.5	32.5-77.0	62.5-152	45.78	11.7-12.0	1.91
Total Length (cm)	6.6-17.1	13.7-17.4	17.3-23.2	16.7	10.2-10.7	6
Standard Length (cm)	5.1-13.6	11.4-14.3	14.0-19.4	12.9	8.1-8.4	4.7
Head Length (cm)	1.8-3.4	3.0-3.6	3.7-4.7	3.4	2.2-2.3	1.5
Head Depth (cm)	1.7-3.0	2.7-3.6	2.9-4.2	2.6	1.6	1.0
Head Breadth (cm)	0.7-2.1	1.4-1.9	1.3-3.0	2	1.1-1.3	0.6
Pre-Orbital Length (cm)	0.5-1.2	0.9-1.3	1.2-1.7	1.2	0.6-0.7	0.4
Post-Orbital Length (cm)	1.1-2.1	1.5-2.0	2.1-2.6	1.9	1.1-1.2	0.8
Snout Length (cm)	0.5-1.2	0.9-1.3	1.2-1.7	1.2	0.6-0.8	0.4
Eye Diameter (cm)	0.5-0.9	0.6-0.7	0.9	0.7	0.5	0.4
Pre-Dorsal Length (cm)	1.8-6.4	5.2-7.7	6.6-8.5	6.2	4.8-05	2.6
Post-Dorsal Length (cm)	2.1-8.7	6.3-8.0	9.0-12.5	8.6	4.0-4.6	3.0
Length of Dorsal fin base (cm)	1.1-8.7	1.5-2.0	2.2-3.0	2.1	1.5-1.8	0.6
Height of Dorsal fin (cm)	0.9-3.5	1.9-2.5	3.5-4.1	3.2	1.5	1.2
Pre-Pectoral Length (cm)	1.8-3.7	3.1-4.5	3.9-4.4	3.3	1.9-2.2	1.4
Post-Pectoral Length (cm)	4.8-14.2	11.3-14.2	14.2-19.8	13.8	8.4-8.7	4.4
Length of Pectoral fin base (cm)	0.3-0.6	0.6-0.9	0.6-0.9	0.6	0.4	0.2
Height of Pectoral fin (cm)	1.2-2.9	2.1-2.6	2.6-3.8	2.8	1.7	1.0
Pre-Pelvic Length (cm)	2.1-7.5	5.6-7.0	6.7-9.0	6.5	3.8-4.1	2.3
Post-Pelvic Length (cm)	4.6-11.2	9.1-11.3	10.4-14.3	9.7	6.7-6.9	3.5
Length of Pelvic fin base (cm)	0.3-0.6	0.4-0.5	0.7-0.9	0.6	0.2	0.2
Height of Pelvic fin base (cm)	1.0-2.6	1.5-1.9	2.4-3.4	2.4	1.1-1.3	0.8
Pre-Anal Length (cm)	2.1-8.0	8.0-9.3	10.2-13.8	9.9	5.3-5.5	2.9
Post-Anal Length (cm)	2.1-6.6	4.9-5.9	6.1-8.3	5.9	3.6-3.7	2.5
Length of Anal fin base (cm)	0.9-2.3	1.6-2.6	1.0-1.4	0.9	1.4-1.5	0.7
Height of Anal fin (cm)	0.8-2.6	1.4-1.9	2.5-3.3	2.5	1.2-1.3	0.8
Body Depth (cm)	2.5-4.1	3.7-4.7	4.3-5.6	3.7	2.4-2.5	1.3
Length of Caudal Peduncle (cm)	0.7-3.2	2.3-3.1	2.9-4.3	2.4	1.5-1.6	1.0
Height of Caudal Peduncle (cm)	0.8-1.7	1.3-1.8	1.9-2.3	1.6	1.0	0.6
Meristic counts						
No. of Pectoral Fin Rays	11-16	12-13	16-16	15	12	12
No. of Spines in Pectoral Fin Rays	1	1	0	0	0	0
No. of Pelvic Fin Rays	5-9	9	9	9	7	7
No. of Spines in Pelvic Fin Rays	1	0	0	0	0	0
No. of Anal Fin Rays	6-8	12	6	6	13	6
No. of Spines in Anal Fin Rays	3	0	0	0	0	0
No. of Dorsal Fin Rays	8-13	8	9	8	11	6
No. of Spines in Dorsal Fin Rays	9	0	1	1	0	0
No. of Caudal Fin Rays	17-19	19	19	19	18	15
Shape of Caudal Fin	Forked	Forked	Forked	Forked	Forked	Forked
No. Lateral Line Scales	27-70	56-64	29-30	27	34	58
No. of Scales above Lateral Line	4.5-9.5	9-10	4.5-5.5	4.5	7.5	8
No. of Scales below Lateral Line	4.5-24.5	8-9	5.5	5.5	2.5-3.5	12
No. of Nasal Barbells	0	0	0	0	0	
No. of Rostral Barbells	2	2	2	2	2	1
No. of Maxillary Barbells	2	2	2	2	2	0
No. of Mandibulary Barbells	–	–	–	–	–	–
Pre-Dorsal Scales	9-20	25-29	10	8	14	18

Table 1b: Morphometric and meristic counts of: *Puntius sophore, Pethia conchonius, Garra kempi, Lepidocephalichthys guntea, Parambassis ranga, Trichogaster lalius*.

	P. soph. (n = 1)	*P. conc.* (n = 1)	*G. kemp.* (n = 1)	*L. gunt.* (n = 1)	*P. rang.* (n = 3)	*T. lali.* (n = 1)
Morphometrics						
Weight (gm)	5.0	8.3	4.9	3.1	8.35-10.5	0.79
Total Length (cm)	7.3	7.4	8.2	7.4	7.5-8.1	3.4
Standard Length (cm)	5.6	5.8	6.5	5.9	5.9-6.5	2.5
Head Length (cm)	1.6	1.7	1.7	1.3	2.1-2.3	1.0
Head Depth (cm)	1.6	1.7	0.9	0.8	2.4-2.7	0.9
Head Breadth (cm)	1.0	1.0	1.1	0.6	0.9-1.1	0.4
Pre-Orbital Length (cm)	0.4	0.5	0.7	0.4	0.6-0.7	0.2
Post-Orbital Length (cm)	0.9	1.0	1.1	0.6	1.3-1.4	0.5
Snout Length (cm)	0.5	0.5	0.7	0.4	0.6-0.7	0.2
Eye Diameter (cm)	0.5	0.5	0.4	0.2	0.7	0.3
Pre-Dorsal Length (cm)	2.9	3.5	3.1	3.5	2.2-2.7	1.2
Post-Dorsal Length (cm)	3.6	3.3	1.1	3.4	2.2-2.6	1.1
Length of Dorsal fin base (cm)	1.1	1.1	1.1	0.5	2.9-3.6	1.3
Height of Dorsal fin (cm)	1.3	1.4	1.7	1.1	1.0-1.3	0.6
Pre-Pectoral Length (cm)	1.5	1.6	1.5	1.3	2.1-2.3	0.9
Post-Pectoral Length (cm)	4.5	6.1	6.6	5.9	5.3-5.9	12.3
Length of Pectoral fin base (cm)	0.3	0.3	0.4	0.2	0.4	0.2
Height of Pectoral fin (cm)	1.1	1.2	1.3	0.9	1.4-1.5	1
Pre-Pelvic Length (cm)	2.7	3.1	3.6	0.3	2.5-2.8	1
Post-Pelvic Length (cm)	4.4	4.7	4.5	4.2	5.4-6.0	2.5
Length of Pelvic fin base (cm)	0.2	0.3	0.3	0.2	0.3-0.4	0.1
Height of Pelvic fin base (cm)	1.2	1.2	1.3	0.8	1.1-1.3	2
Pre-Anal Length (cm)	4.0	4.5	5.2	4.6	0.9-4.1	1
Post-Anal Length (cm)	2.7	2.8	2.6	2.3	2.5-5.9	0.9
Length of Anal fin base (cm)	0.7	0.8	0.5	0.5	0.9-2.4	1.7
Height of Anal fin (cm)	1.0	0.9	1.2	1.0	0.9-2.5	0.6
Body Depth (cm)	1.9	3.0	1.1	1.0	3.1-3.5	1.3
Length of Caudal Peduncle (cm)	1.2	1.0	1.0	1.0	0.9-1.0	0.2
Height of Caudal Peduncle (cm)	0.8	0.9	0.7	0.8	0.8-1.0	0.4
Meristic counts						
No. of Pectoral Fin Rays	14	8	11	8	9.0-12	5
No. of Spines in Pectoral Fin Rays	0	0	0	0		0
No. of Pelvic Fin Rays	9	8	9	6	5	1
No. of Spines in Pelvic Fin Rays	0	0	0	0	1	
No. of Anal Fin Rays	6	6	6	6	14-16	8
No. of Spines in Anal Fin Rays	0	0	0	0	3	17
No. of Dorsal Fin Rays	8	7	8	7	13-15	9
No. of Spines in Dorsal Fin Rays	1	1	0	0	8-9	14
No. of Caudal Fin Rays	18	17	18	16	17-18	16
Shape of Caudal Fin	Forked	Forked	Emarginate	Rounded	Forked	Wedge
No. Lateral Line Scales	26	25	35	112	70-73	26
No. of Scales above Lateral Line	4.5	5.5	4.5	13	10.5	4.5
No. of Scales below Lateral Line	4.5	5.5	5.5	13	25.5-32.5	8.5
No. of Nasal Barbells	0	0	0	0	0	0
No. of Rostral Barbells	0	1	2	2	0	0
No. of Maxillary Barbells	0	0	2	2	0	0
No. of Mandibulary Barbells	0	0	0	2	0	0
Pre-Dorsal Scales	8	11	12	54	0	11

Table 1c: Morphometric and meristic counts of fish: *Barilius barila*, *Chanda nama*, *Mystus bleekeri*, *Esomus danrica*, *Danio dangila*, *Opsarius dimorphicus*.

	B. baril. (n = 3)	*C. nama* (n = 1)	*M. bleek.* (n = 1)	*E. danr.* (n = 3)	*D. dang.* (n = 4)	*O. dimo.* (n = 4)
Morphometrics						
Weight (gm)	10.1-12.1	3.89	3.9	0.9-1.5	2.1-2.8	32.5-63.9
Total Length (cm)	10.4-11.5	7.6	7.8	4.2-5.3	5.0-6.6	13.7-16.3
Standard Length (cm)	802-9.1	5.8	6.1	3.1-4.0	4.5-5.1	11.4-13.6
Head Length (cm)	2.1-2.2	2.0	1.8	0.9-1.1	1.1-1.4	3.0-3.5
Head Depth (cm)	1.7-1.9	1.7	1.1	0.6-0.7	0.8-0.9	2.7-3.3
Head Breadth (cm)	0.9-1.0	0.7	1.2	0.4-0.5	0.6-0.7	1.4-1.8
Pre-Orbital Length (cm)	0.6-0.7	0.6	0.7	0.2-0.3	0.3-0.4	0.9-1.1
Post-Orbital Length (cm)	1.1-1.3	1.1	1.0	0.4-0.6	0.6-0.7	1.5-1.8
Snout Length (cm)	0.6-0.7	0.6	0.7	0.2-0.3	0.3-0.4	0.9-1.1
Eye Diameter (cm)	0.5-0.6	0.5	0.3	0.2-0.3	0.4	0.6-0.7
Pre-Dorsal Length (cm)	4.5-4.9	2.1	2.5	2.2-2.7	2.6-3.0	3.3-6.6
Post-Dorsal Length (cm)	4.5-5.1	3.1	4.5	1.2-2.3	2.4-2.7	6.3-6.8
Length of Dorsal fin base (cm)	1.1-1.2	3.2	0.9	0.3	0.7-0.9	1.5-1.8
Height of Dorsal fin (cm)	1.6-1.8	1.0	1.1	0.7-0.9	0.8-1.1	1.9-2.3
Pre-Pectoral Length (cm)	2.1-2.6	1.8	1.6	0.8-1.1	1.1-1.2	3.1-4.1
Post-Pectoral Length (cm)	8.2-8.7	5.6	5.9	2.7-4.0	4.7-5.3	11.3-13.5
Length of Pectoral fin base (cm)	0.4-0.5	0.3	0.3	0.2-0.3	0.3	0.6-0.8
Height of Pectoral fin (cm)	1.7-1.9	1.2	1.2	1.2-1.4	1.2-1.4	2.1-2.2
Pre-Pelvic Length (cm)	4.0-4.4	2.3	3.3	1.8-2.2	2.1-2.5	5.6-6.6
Post-Pelvic Length (cm)	6.4-7.0	5.4	4.3	1.8-2.9	3.7-4.2	9.1-11
Length of Pelvic fin base (cm)	0.4	0.2	0.2	0.2	0.2	0.4-0.5
Height of Pelvic fin base (cm)	1.1-1.2	1.0	1.1	0.6-0.9	0.8	1.4-1.6
Pre-Anal Length (cm)	5.2-5.6	3.3	4.4	2.3-3.1	2.9-3.4	8.0-9.1
Post-Anal Length (cm)	3.2-4.0	2.5	2.6	1.1-1.8	2.0-2.2	4.9-6.1
Length of Anal fin base (cm)	1.2-1.4	2.1	0.8	0.3-0.4	0.9-1.2	1.6-2.4
Height of Anal fin (cm)	1.3-1.4	1.8	1.3	0.8-1.0	0.8-1.1	1.4-1.7
Body Depth (cm)	2.2-2.6	2.2	1.4	0.6-0.8	0.9-1.2	3.7-4.4
Length of Caudal Peduncle (cm)	1.5-1.9	0.9	1.1	0.6-0.7	0.7-0.8	2.3-3.2
Height of Caudal Peduncle (cm)	0.9-1.0	0.7	0.7	0.3-0.4	0.4-0.5	1.3-1.6
Meristic counts						
No. of Pectoral Fin Rays	12	11	6	9-10	12	12-13
No. of Spines in Pectoral Fin Rays	1	0	1	0	0	1
No. of Pelvic Fin Rays	9	5	6	5-6	7	9
No. of Spines in Pelvic Fin Rays	0	1	0	0	0	0
No. of Anal Fin Rays	12	15	8	6	15	12
No. of Spines in Anal Fin Rays	0	3	0	0	0	0
No. of Dorsal Fin Rays	8	16	7	7	10	8
No. of Spines in Dorsal Fin Rays	0	11	1	0	0	0
No. of Caudal Fin Rays	19	14	18	18	18	19
Shape of Caudal Fin	Forked	Forked	Forked	Forked	Forked	Forked
No. Lateral Line Scales	39-44	95	0	23-26	29-33	54-62
No. of Scales above Lateral Line	6-7	11	0	3.5-4.5	2.5-4.5	9-10
No. of Scales below Lateral Line	6	13	0	3.5-4.5	4.5	8-9
No. of Nasal Barbells	0	0	2	0	0	0
No. of Rostral Barbells	2	0	0	2	2	2
No. of Maxillary Barbells	2	0	2	2	2	2
No. of Mandibulary Barbells	0	0	4	0	0	0
Pre-Dorsal Scales	16-17	0	0	8	15	24-27

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