Calculation of Habitat Preference Curves of *Cryphiops caementarius* in the Tambo River, Arequipa - Peru; for ecological flow determination

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ABSTRACT

In holistic methods for calculating the ecological flow, two groups of data are required, the hydrotopographic data of the river to be studied and the habitat preference curve of an indicator species; In the case of the rivers of southern Peru, the indicator species considered is the river shrimp *Cryphiops caementarius*; on the other hand, there is interest in knowing details of the habitat of the mentioned species due to its ecological, economic and social importance; That is why it is proposed to determine the habitat preference index of *Cryphiops caementarius* in the Tambo River, and from these to calculate and construct the habitat preference curves. For this, 1810 individuals of *C. caementarius* are captured. At the capture points, the depth, the total velocity, the focal velocity, and the type of substrate are determined; obtaining from this information the habitat use indices. On the other hand, in the same sampling area, 45 transects are established through the river considering the most representative areas (tablazos, rapids, backwaters, etc.), in them we proceed to take measurement of depth, total speed and substrate in a total of 349 points; With this information, the habitat availability index is determined; Then, by relating these two indices (index of use / index of availability) the index of habitat preference is obtained, with which the preference curves are constructed. The resulting values obtained show that a higher frequency of individuals of *C. caementarius* prefer depth between 0.20 and 0.40 m; Regarding the preference of total speed, a higher frequency is observed at 0.11 m / s, however, a uniform distribution is observed between 0.4 and 1.5 m / s and within the substrate there is a preference for "edges" (rocks between 64- 256 mm).

Keywords: *Cryphiops caementarius*, Usage Index, Availability Index, Preference Index, Substrate

INTRODUCTION

It must be established initially that river shrimp (*Cryphiops caementarius*), is a species whose worldwide distribution is centered from the northern part of Chile to the central part of Peru (Hartman 1958, Bahamonde & Vila 1971, Cortez, 1999, Meruane et. al. 2006), fundamentally linked to the western slopes; However, the most important populations of this crustacean are found in the Tambo, Majes - Camaná and Ocoña rivers (Bocardo 1990,

Llipita 2002, Reyes & Lujan 2003, Reyes et. al. 2006, Yepes & Zacarias 2008, Wasiw & Yepes 2015)

Based on the need to use water resources to meet the needs of human populations, such as agriculture, electricity generation, population use and others; there is no doubt that the habitats of *Cryphiops caementarius* will be affected (Jansson et. al. 2000, Pettit et. al. 2001, Bocardo 2002, Allan 2004, Kennard 2006); even more so if at present the strategies for climate change adaptation consist of the regulation of affected basins (Jansson et. al. 2000, Pettit et. al. 2001, Kennard 2006) since the expected effect corresponds to droughts; It is therefore important to know which are the habitat preferences that this crustacean presents in order to be able to propose adequate protection measures and avoid the loss of this resource in the aforementioned rivers (Portugal et. al. 2003, Azañero & Lujan 2004 , Yavar & Dupre 2007).

The present investigation has been developed in the Tambo River, mainly due to being one of the rivers with the largest populations of *Cryphiops caementarius* and having important water flows (Yepes & Zacarias 2008, Wasiw & Yepes 2015).

The objectives set for the present investigation were to determine the habitat preference indices for tie (depth) and total velocity, also considering the substrate and thereby construct habitat preference curves for *Cryphiops caementarius*.

MATERIAL AND METHODS

Study area

The present work was carried out in a section of the Tambo River, Islay Province, Arequipa Region. Between 695454.87 - 8227999.16 (UTM) and 695326.60 - 8228596.62

The criteria considered for the choice of the study area were mainly the following: that there is representativeness of the scenarios in the river (rapids, tablazo, backwater areas, etc.) (Diez 2004) and also the presence of "shrimp", this The last one was consulted with the fishermen of the area who later carried out the sampling.

Sampling.

The sampling was carried out from August to December from 2017 to 2018.

Once the starting point of the sampling was defined, 8 experienced fishermen entered the river, which were located equidistant across the entire riverbed (Yepes & Zacarias 2008, Wasiw & Yepes 2015). With the help of diving equipment, they were collecting shrimp specimens; the collection site was conveniently signposted; Only adult specimens were considered, which for this study are represented by organisms with sizes ranging from 3 cm to more, considering that they have benthic behavior (Reyes & Lujan 2003, Reyes et. al. 2006).

The collection was carried out until 1810 shrimp specimens were obtained; At each marked point, the tie, mean velocity, focal velocity and substrate were measured. The velocities

were taken with an Ott brand currentometer model MF PRO N / S 336150. The shelter used by the shrimp specimens was also considered.

Depth.- the depth is measured in meters in each of the points where a shrimp was found, it should be mentioned that in all the shrimp were found in inferior lateral areas of the stones, thus for the measurement of the tie it was taken from the surface where the stone that served as a refuge for the shrimp rested.

Average Speed and Focal Speed.- In each of the points marked by the presence of shrimp, the mean and focal speed are measured. For this, an Ott currentometer model MF PRO N / S 336150 (precision 0.01 m / s) was used.
The average velocity in the water column was calculated as follows: when the tie is greater than 70 cm, the velocity was measured at two depths, equal to 80% and 20% of the tie; the average of the two measurements is the mean velocity of the water column. Where the tie is less than 70 cm, a single measurement was made, at a depth equal to 60% of the tie at that point (Martínez & García 1999, Pouilly & Aguilera 2012).
Focal velocity is defined as the velocity found at the specimen's collection point, which for the present case was always at the bottom, since the river shrimp, in its adult state, is benthic. (Reyes & Lujan 2003, Reyes et. Al. 2006).

Substrate Type.- For the type of substrate I use the criteria observed in Table No. 1 (García & Diez 2013)

Code	Sustrate	Average size
1	**Bedrock**	**Continuous**
2	**Big blocks**	**>1024 mm**
3	**Blocks**	**256-1024 mm**
4	**Chants**	**64-256 mm**
5	**Gravel**	**8-64 mm**
6	**Gravel**	**2-8 mm**
7	**Sand**	**0.62 – 2 mm**
8	**Silt**	**<0.62 mm**
9	**Vegetation**	**-**

Table No. 1
Characterization of the Substrate considered in the Determination of Habitat Preference

Source: García y Diez 2013

Refuge.- The refuge identified in 100% of the captured individuals corresponds to the lower lateral zones of "Block" and "Chant" (between 64 and 1024 mm). It was observed in the river areas that presented the same substrate, but the disposition of the stones it was given in such a way that its inferior lateral areas were not exposed; the fishermen call this area "sown stone zone" in which there is no shrimp, presumably because it does not have shelter.

Submerged vegetation on the banks was not observed in the study area, therefore they have not been considered. Everything previously considered corresponds to the information necessary to determine the Habitat use rate. (Martínez & García 1999, Diez 2004, García & Diez 2013)

For the determination of Habitat Availability, 45 transects have been made, located in such a way that they adequately represent the longitudinal heterogeneity of the section (deep pool areas, tables, rapids, etc.) and so that the measurement points in each one reflected the topography of the bed and the hydraulic conditions of the section taken (IFIM habitat physical simulation methodology). From these data it is possible to study the presence of areas with different depths, speeds, types of substrate and availability of shelter that exist in the study section. This is very important, since the preference of the shrimp is a function of the ecological spectrum of the species and the available habitat. (Martínez & García 1999, Diez 2004, García & Diez 2013).

Calculation of the Preference Curve

The habitat preference curve was determined by plotting the Habitat Preference Index (HPI) related to the habitat use index (IUH) by the habitat availability index (HDI). (Martínez & García 1999, Diez 2004, García & Diez 2013)

$$IPH = IUH / IDH$$

Habitat Use Index (IUH) .- The habitat use index was determined for tie, mean speed, focal speed and substrate for the latter, only a histogram that included percentages was considered. In the case of the tie, mean speed and focal speed, a frequency distribution was made, and based on the higher frequency the curve was adjusted to 1. (Martínez & García 1999, Diez 2004, García & Diez 2013)

Habitat Availability Index (HDI) .- The habitat availability index for tie, mean speed and substrate was determined for the latter, only a histogram that included percentages was considered. In the case of the tie and the average speed, a frequency distribution was carried out, and based on the highest frequency of adjusting the curve to 1. It was not

considered necessary to establish a representativeness adjustment of the transect since it was very similar in all (between 5 and 6%) (Martínez & García 1999, Diez 2004, García & Diez 2013)

Habitat Preference Index.- The division between the Use Index and the availability index is made and adjusted to 1 to obtain the habitat preference curve. . (Martínez & García 1999, Diez 2004, García & Diez 2013).

RESULTS AND DISCUSSION

Habitat Use Index

The results of the habitat use index are obtained for 1810 *Cryphiops caementarius* specimens, initially considering the depth (depth) where the use index for this characteristic corresponds to 0.42 m, having a more or less even distribution on both sides; as can be seen in figure N ° 1.

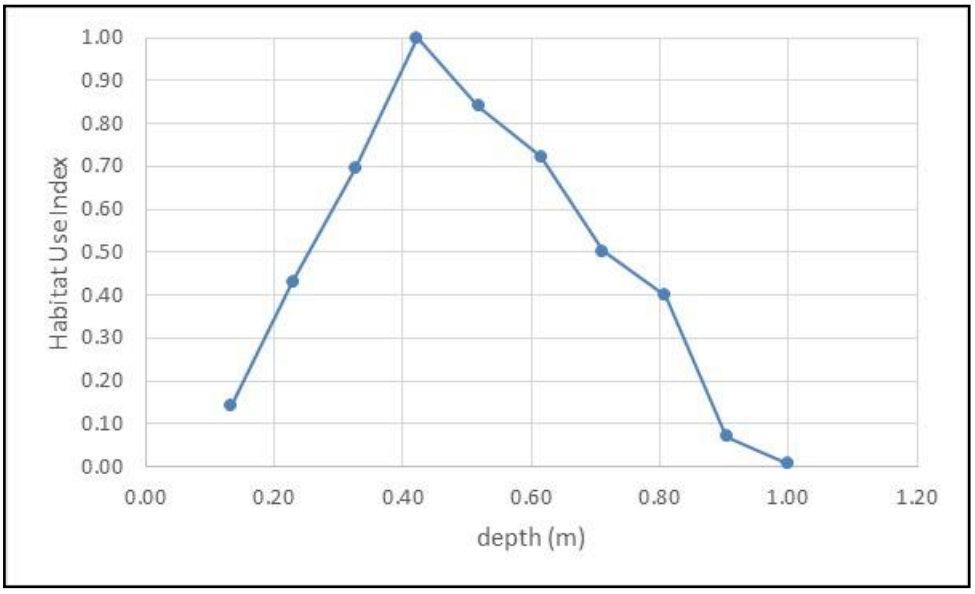

Figure No. 1 Habitat use curve for the *Cryphiops caementarius* depth in the Tambo river

Cryphiops caementarius specimens have been found from 0.1 m. up to 1 m deep with the highest frequency in the 0.42 m. finding a difference with the value of 0.22 reported by Pouilly and Aguilera (2012) who collected only 36 individuals, Reyes and Col (2006) found a relationship between the tie and salinity, a factor that could explain the difference between the results obtained and those of Pouilly and Aguilera (2012), however, could also be due to the sample size.

For the case of total velocity, it is observed that the highest index of habitat use is 0.69 m / s; and the distribution, as can be seen in figure N ° 4, has a tendency towards lower speed; It should be remembered that since the works of Hartman (1958) the negative rheotactic

behavior of this species has been established (going against the current) (Meruane et. al. 2006), however, this is an activity that generates natural selection on the resource, so the stronger the specimen, it can rise higher in the basin, as a greater force of water overcomes; However, lower speeds would allow a greater number of individuals on the rise. Pouilly and Aguilera (2012) found a total velocity of 0.33 m / s which is less than that reported in the present study

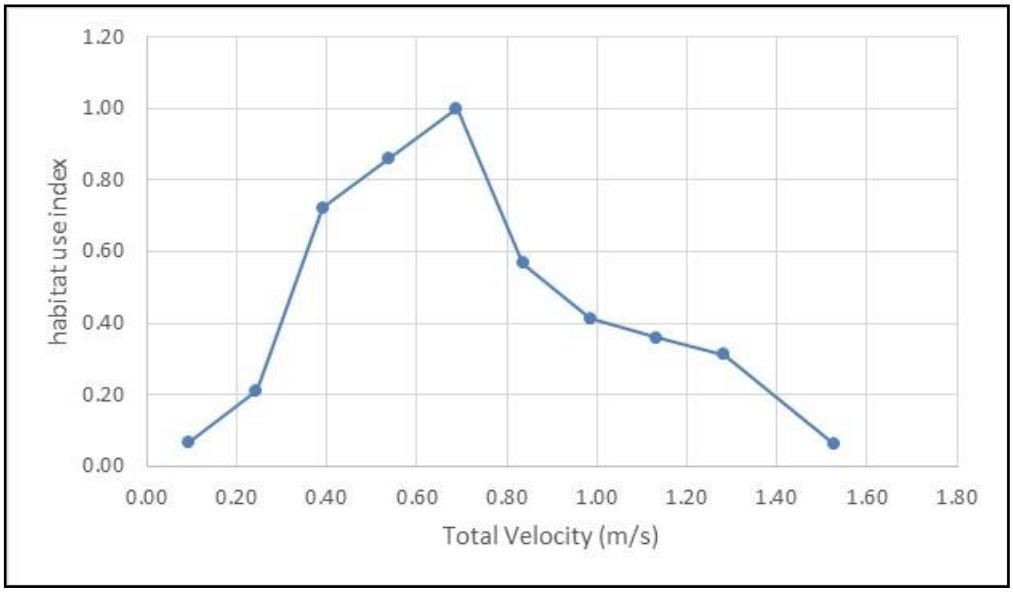

Figure No. 2 Habitat use curve for Total Velocity of *Cryphiops caementarius* in the Tambo river

It was considered important for the habitat use case to determine the focal speed use index. (Martínez & García 1999, Diez 2004, García & Diez 2013), which by definition is the speed of the water where the specimens are found, in this case, as it is a benthic species, the focal speed was taken at the bottom (where the found the specimens), Figure N ° 3 shows the curve of habitat use for focal velocity where the highest value corresponds to a velocity of 0.30 m / s, the highest frequency being at lower velocities, which is consistent with what was observed at full speed.

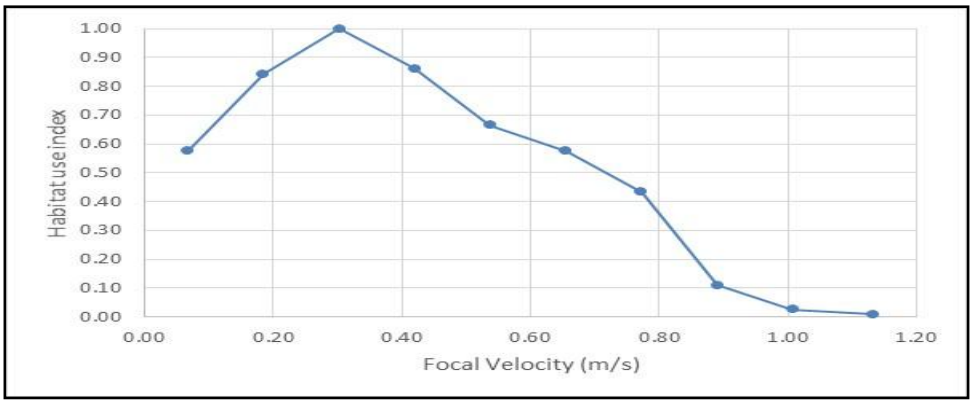

Figure No. 3 Habitat use curve for Focal Speed of *Cryphiops caementarius* in the Tambo river

Regarding the substrate, the specimens were found 86.07% in a substrate called "edges" (64-256 mm) and 13.93% in the so-called "Blocks" (256-1024 mm): *Cryphiops caementarius* seeks refuge and protection against force of water in this type of substrate (Bocardo 1990, Llipita 2002, Reyes & Lujan 2003, Reyes et. al. 2006, Yepes & Zacarias 2008, Wasiw & Yepes 2015), which must be related to the force of water presented by the Tambo river; This could be verified by observing stones with buried edges ("sown stone") on which no specimen was found since they did not provide the necessary protection for the specimens.

Habitat Availability Index

Of the 45 transects analyzed in the study area, 349 measurement points were established and the index of use for the tie parameter was determined, finding the highest value for 0.52 m but maintaining a more or less regular distribution as can be seen in figure N ° 4

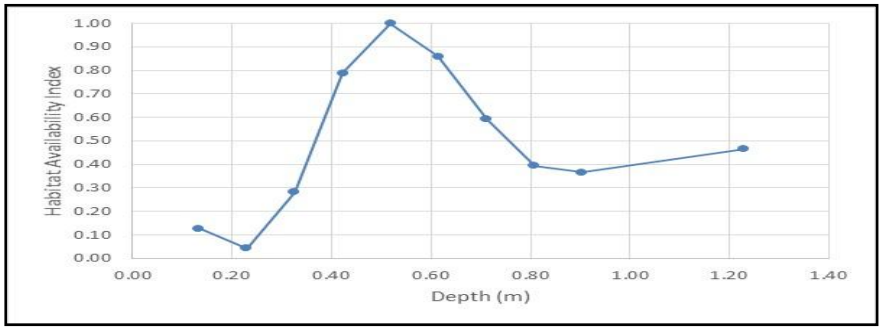

Figure No. 4 Habitat Availability Curve for depth of *Cryphiops caementarius* in the Tambo River

Regarding the availability of habitat for *Cryphiops caementarius* in total velocity, the highest value of the index is observed at 0.69 m / s, the most frequent values being the lowest to the index mentioned as can be seen in Figure N ° 5

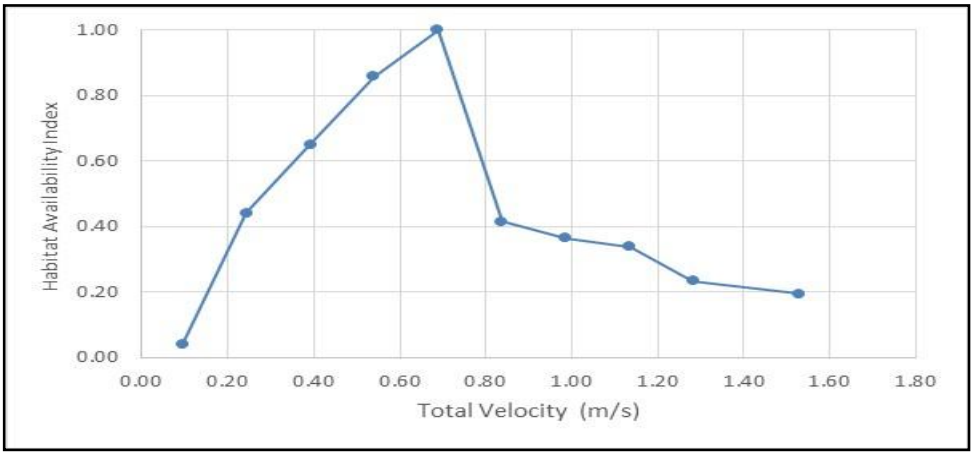

Figure No.5 Habitat Availability Curve for *Cryphiops caementarius* total velocity in the Tambo River

When considering the availability of habitat for substrate, it is observed that the highest percentage corresponds to the substrate defined as "edges" (64-256 mm) with 76.19% followed by the substrate called "Blocks" (256-1024 mm) with 23.37% that if it is compared with the registered in the index of use of habitat it is noticed that the values coincide.

Habitat Preference Index

By relating the use index and the availability index, we can determine the preference index (Martínez & García 1999, Diez 2004, García & Diez 2013). Thus we have that in the case of the tie, the best performance (Preference index equal to 1.0) of the shrimp is obtained in the order of 0.28 m .; with tie rods from 0.40 to 1.0 m the preference is reduced, as well as between 0.10 and 0.20, the highest proportion being observed between 0.20 and 0.40 m. As can be seen in figure N ° 6; The interpretation of the aforementioned preference curve is given by the fact that of the entire spectrum of ties offered by the Tambo River, the largest proportion of the sample of shrimp taken prefers depth between 0.20 and 0.40 m.

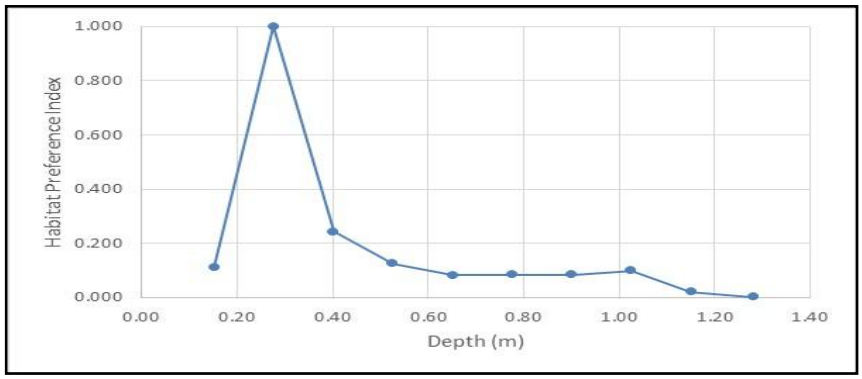

Figure No. 6 Habitat Preference Curve for depth of *Cryphiops caementarius* in the Tambo River

For the case of total velocity, the highest habitat preference index is observed at velocities in the order of 0.11 m / s. However, it should be noted that there is a more or less similar preference between 0.4 and 1.5 m / s, which can be interpreted as that the fundamental element is not the speed but the availability of shelter

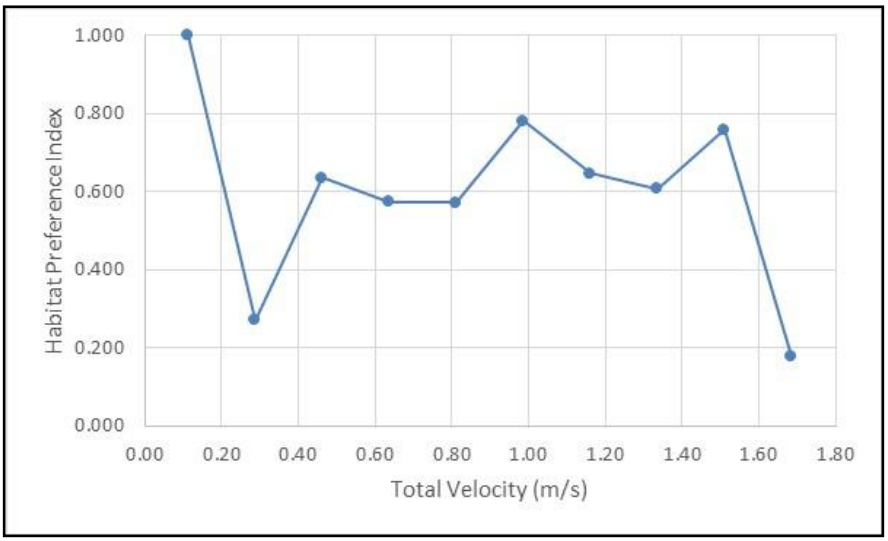

Figure No. 6 Habitat Preference Curve for Total Velocity of *Cryphiops caementarius* in the Tambo River

In the case of the substrate, the one with the greatest preference for *Cryphiops caementarius* is the one called "edges", with a value that is considerably less than that of the substrate called "blocks".

CONCLUSION

The habitat preference indices for *Cryphiops caementarius* determined in the Tambo River correspond to 028 m of tie, 0.11 m / s of total velocity and a substrate called “cantos” (64-256 mm). Habitat preference curves are constructed showing ranges for the case of tie between 0.20 and 0.40 m and for the total velocity between 0.4 and 1.5 m / s

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