D5 Qualitative and quantitative hydrological monitoring

LIFE Tritó Montseny (LIFE15 NAT/ES/000757)

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Joan Gomà[1,2] & Francesc Sabater[1].
[1]Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals.
Universitat de Barcelona
[2]FEHM-Lab (Freshwater Ecology, Hydrology and Management)

Summary

During the LIFE project, a great amount of work has been carried out to understand and monitor the habitat of the Montseny newt. From the initial in-depth characterisation to the detailed study of the impact of the actions carried out by the project, including the implementation of a network to monitor the flow and temperature of the streams in the upper Tordera basin. The network consisted of sensors for continuous data collection at one point and periodic visits to assess the hydrological status of a section.

The initial characterisation made it possible to define the homogeneity of the environmental characteristics of the streams. The monitoring network has provided the necessary time series of data to determine the hydrological dynamics of the streams and their relationship with rainfall. The data from the sensors show the torrential character of the streams and the field monitoring shows the resilience of a minimum flow, often with subsurface circulation sections in most of them. The lack of rainfall over the last year is beginning to be reflected in some streams that have gone dry for the first time in the 5 years of monitoring.

This monitoring has provided unprecedented information on basal flows, which are essential for water use management, as they have been very low: below 1 L/s in many of the streams.
The impact of the actions on the habitat was assessed in a number of ways. The deposition of sediment in the actions to restore the continuity of the stream has been shown to be very punctual downstream of the action and not very long-lasting in time. The change in water temperature due to the action on the riparian vegetation was shown to be small and variable between seasons, with a slight increase in warm periods and a slight decrease in cold periods.

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Introduction

The Montseny newt is mainly found in the upper reaches of streams that have low basal flows, mainly due to the small surface area of the sub-basins. For this reason, the flow of these streams is very sensitive to changes in the weather, water withdrawals and channel alterations.
Among the alterations, an important one is the presence of tracks that cross the streams. The material accumulated in the channel to allow the passage of this track has been shown to interrupt the continuity of the torrent. The circulating water infiltrates when it reaches this material and circulates sub-surface. Often this interruption extends beyond the area affected by the track and the water does not reappear on the surface until some distance away. This lack of surface circulation may be crucial for the connectivity of newt populations growing in the same stream.

Water temperature has also been shown to be linked to the plant cover of the bank and the shade it provides, in addition to the weather.

Actions that have been carried out and are planned will affect these problems. We are therefore monitoring the flow, hydrological status and temperature of a number of streams within the newt's geographical distribution.

Long term hydrological monitoring

Flow regime

In order to monitor the flow of the brooks, pressure sensors were installed in different brooks in the upper reaches of the Tordera. pressure sensors were installed in different streams in the upper reaches of the Tordera, in Montseny.

These sensors continuously measure the water flow. They are installed in a small pool in the river bed inside a tube that acts as a small well. This method is very minimally invasive as it does not involve any modification of the river habitat. Unfortunately, we found that the streams in which the newts live have a very high the newt have very torrential responses, which the conventional installation of conventional sensor installation could not cope with.
The experience allowed us to learn about the installation of this type of sensors in the streams where the newt lives.

The data obtained in the first few years are patchy and not all are valid For various reasons, such as the accumulation of sediments and the directly the displacement of the tube containing the sensor with the floods, but also the periods of but also periods of non-circulation of water where the sensor signal but no flow was indicated by the sensor. This was checked with the information from the Hydrological Status monitoring.

Fig. 1: Sensor installations in brooks with steel pipes and anchored to rock blocks. October 2021.

The results of the quantification of the flow shows us which is the regime of the brooks.
During the project, a network of sensors has been set up in 7 streams. The flow of the brooks has a behaviour linked to the rainfall as expected. as expected. They often have torrential floods due to their steep slope which confers enough energy to the water, even if it is not very abundant.
These streams cover the typological diversity of streams in the upper Tordera basin. Although they are all typical headwater streams with the morphology that characterises them: steep slopes, narrow and encaged channels with few branches and a narrow or almost non-existent strip of riparian vegetation, there are differences between them that can lead to variations in the hydrological regime.

On-site flow measurement is carried out using the method of adding a neutral tracer (salt). The value obtained allows the sensor data to be calibrated. Over the course of the project, 290 flow data points have been collected, providing information on the hydrology of the streams. The flow data for the las 3 years are shown in Figure 2 and it can be seen that the B5 is the site with the highest flow, an order of magnitude above the others. El A1 is also more equestrian than the others. Both are the watercourses with the largest sub-basins of the streams studied, although B5 is by far the largest. However, A2 and A3 are similar to the A1 and have much lower flows.
The brooks have a basal flow that is in most cases very low, less than 4 l/s, and in the smaller basin brooks a basal flow of less than 1 L/s is recorded.
The limit of 4L/s is important because it is the limit set by the Catalan Water Agency - the administrative body in charge of water management in Catalonia - to allow the exploitation of a watercourse.

These data show a very low amount of water circulating under basal conditions. This implies that they have little margin if rainfall drops, so the possibility of running out of water is high.

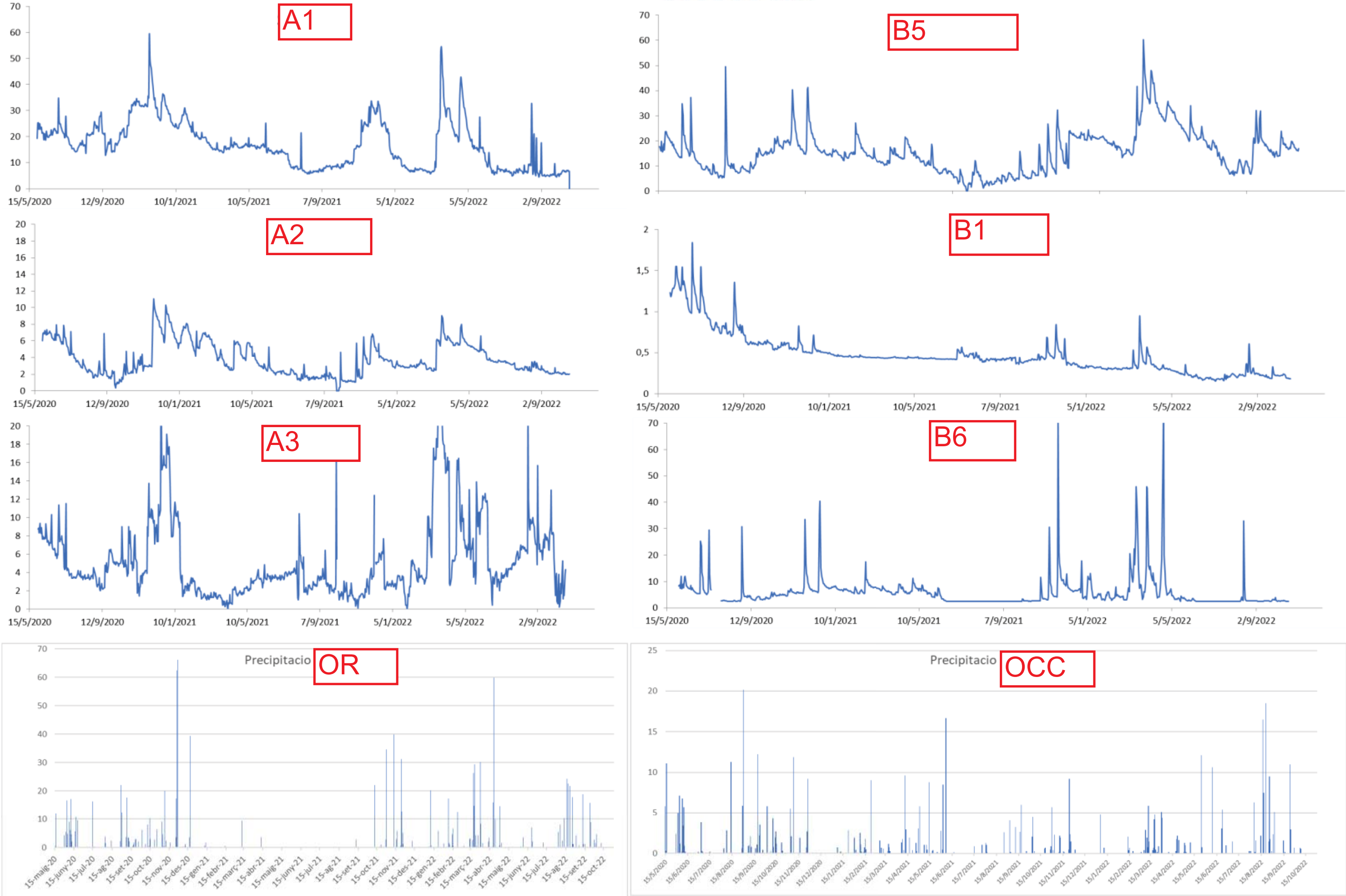


Fig. 2: Flows (L/s) calculated from the data of the stream pressure sensors. Left column: streams on the east slope, right column: streams on the west slope. Last row: Daily precipitation (L/m2) of the eastern (left) and western (right) slopes.

Values are shown since May 2020, when the sensors were last installed and the data series is constant and reliable.

Hydrological State

The stream flow data is complemented by a description of the hydrological status, which tells us whether the water flow is interrupted or not, whether there are pools and their dimensions, and whether the stream is 'completely dry'. The information on the hydrological condition of the watercourses that can be obtained by visiting them in person cannot be obtained by sensors. By observing the stream, it is possible to determine whether the water flow is continuous, superficial or interrupted, whether there are pools with underground circulation or whether it has even stopped. And, above all, in which period of the year there is a possible interruption of the surface circulation and how long it lasts.
A total of 289 visits have been made to the 12 torrents, mainly by rangers from Montseny Park. The period of time is of 6 years, with their 6 dry seasons, . The periodicity is uneven, trying to make more visits in the transition periods towards the summer season and the period of increased autumn flow. The frequency of visits has been adjusted based on the first data.
The frequency of visits in recent years has been greatly reduced, to just 2-3 visits per locality, the minimum reached in 2020 due to the pandemie.

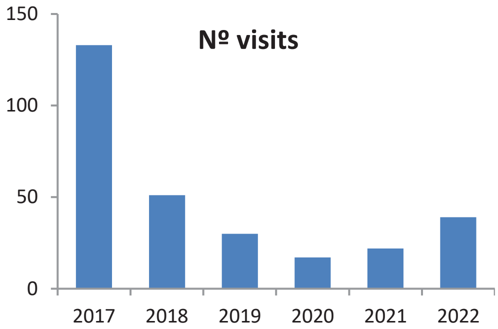


Fig. 3: Total number of visits per year to assess hydrological status for all brooks.

The sensitivity of stream flow to low rainfall is shown by the hydrological status data: in 2019, many streams were in the Archaic state: the stream section has only isolated ponds, with no water circulating on the surface. Even one stream - TXT12 - reached the hyporheic state without surface water. This year, spring rainfall was very low and temperatures were higher than normal (Fig. 9 and 2). In 2020, there is not much rain either, but there is a very rainy February, which seems to maintain the water circulation in the torrents. However, the frequency of visits needs to be increased to ensure this.
In fact, the data show that only two of the sites with newts always have circulating surface water: B5 and TXT8. Although A1 and A3 were only in an archaic state (disconnected ponds) during one visit, in December 2017 and August 2017 respectively. The other streams had more periods in which the surface water was in disconnected ponds. The most pronounced is B1 followed by the B4 and, to a lesser extent, the B2.
It seems, therefore, that the lack of surface water during dry periods is variable and probably related to rainfall. And that there are streams that are more affected by this drought and that lose surface water for a longer period of time, as is the case of B1, B2 and B4.
Actually, in the last two years, rainfall has decreased significantly and it has been observed that some streams have reached the dry state of the bed: A1 and B1.

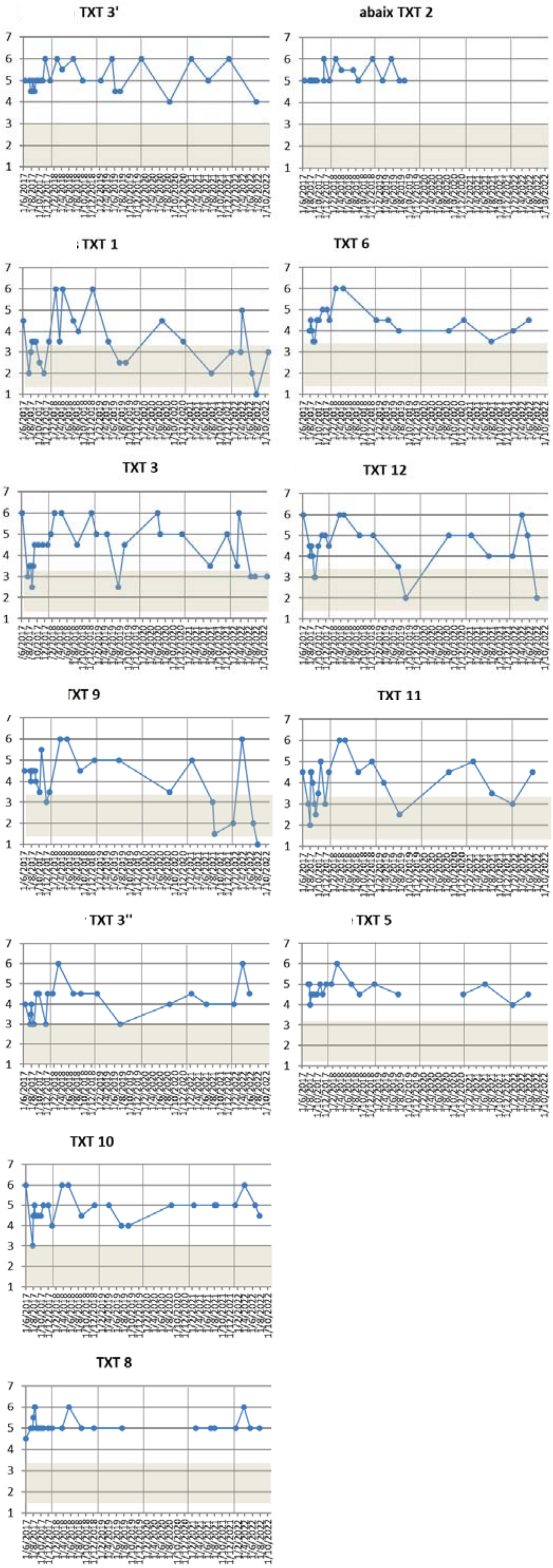
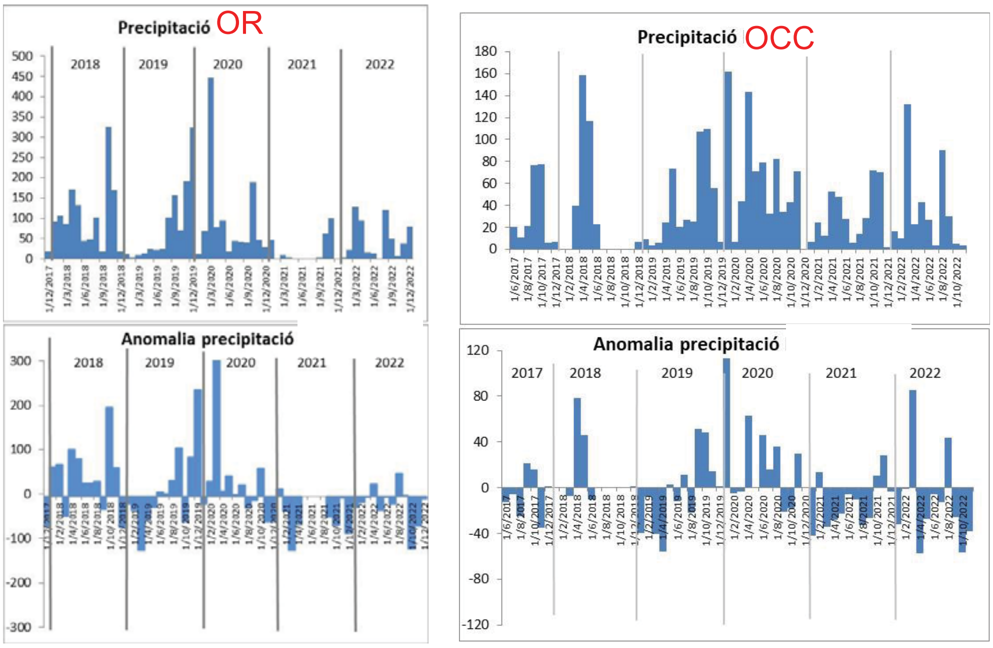


Fig 4: Hydrological status of the 12 streams. From Dry (1) to Hyperrheic (7). The shaded area indicates states where there is no surface water circulation. Left column: Streams with the presence of newts, right column: streams with the absence of newts. Vertical grey lines indicate the months of January.

Fig 5 Monthly rainfall at the easter sector and weastern sectorweather stations. The vertical lines mark the months of January. Bottom: Difference of the monthly temperature with respect to the average of the time series.



Other places have always had a very constant hydrological situation, with a continuous flow of water. Those in the right of the (fig x. It seems that the springs or wells also influence the hydric state in summer, since the sections that have them have never been found in an archaic state, with the surface flow interrupted. For example, TXT8, Tram 5 and A3.

These data show that the hydrological regime of the different localities where the newt lives has a different dependence on rainfall: there are streams whose hydrological regime is highly dependent on rainfall, as would be the case of B1 or B2, probably because they are small
drainage basins. And there are others that are more independent: Cas de la B5 or TXT8.
In the first case, because the town has a large catchment area, and in the second, because it is close to a spring.

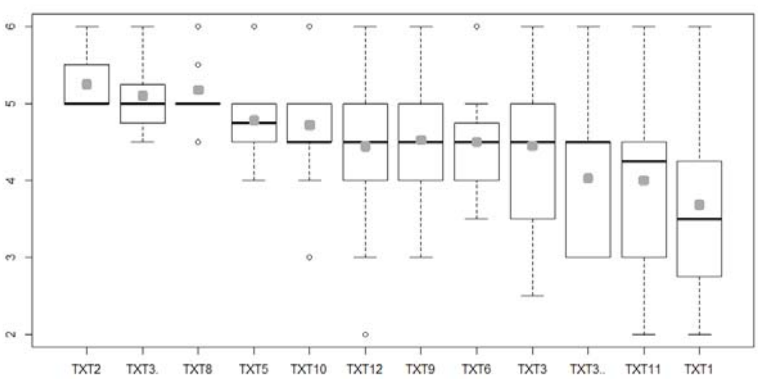


Fig. 6: Mean and variance of the hydrological status of the streams during the monitoring period.

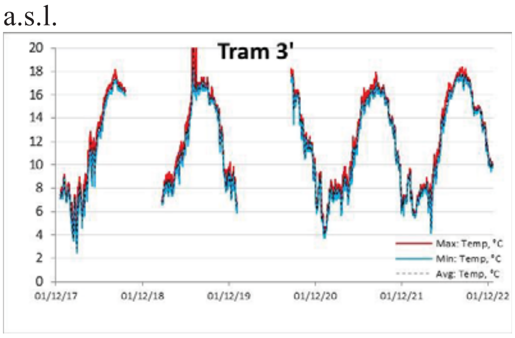
Monitoring of the hydrological status has shown that the streams have never been completely dry during the dry season.
On the other hand, many other streams have maintained a hydrological state with surface water circulation even in this drought scenario.

There is therefore a difference in the hydrological behaviour of the streams. These data show that the hydrological regime of the different habitats in which the newt lives depends on rainfall in different ways: there are streams whose hydrological regime is highly dependent on rainfall, as in the case of B1 or B2, probably because they are small catchment areas. And there are others that are more independent: Cas de la B5 or TXT8. In the first case, because the town has a large catchment area, and in the second, because it is close to a spring.

Water Temperature

The automated collection of temperature data began in winter 2017 with the installation of datalogger sensors, and the data series exceeds 6 years, allowing us to know the temperature dynamics of the torrents in the upper Tordera basin, the newt's habitat.
As expected, all the streams respond to the annual cycle of air temperature, especially to the evolution of the maxima, where almost all the streams had a maximum temperature in the summers of 2021 and 2022, where values were recorded average maximum temperatures higher than the other years. The B5, TXT8 and TXT5 sections are the ones that have buffered this increase the most. The points of the B5 are those with an upper drainage basin and the TXT8 and TXT5 pass through a beech forest. Both these factors can act as a buffer for the water temperature. Although A2 is also located in a beech forest, it clearly shows the increase of the ambient temperature in summer.
The annual temperature profiles show some differences between the streams. B1, TXT12 and TXT8 are the ones with less intra-annual variation: the annual thermal amplitude varies around 8ºC, while in the others it is between 10 and 13ºC.
The altitude of the sites where the sensors are located is reflected in lower temperatures, especially in the winter months.

Fig. 7: Daily evolution of maximum (red) and minimum (blue) monthly temperature (ºC) from 2017 to 2022. Right column streams with newts, left column streams without newts. Streams sorted by increasing altitude a.s.l.



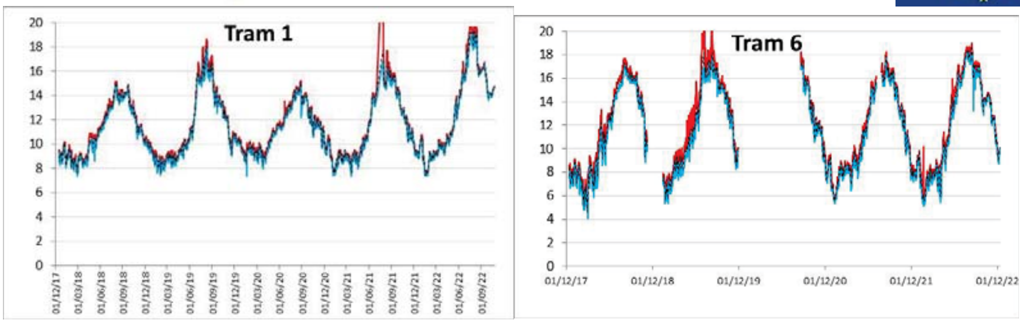
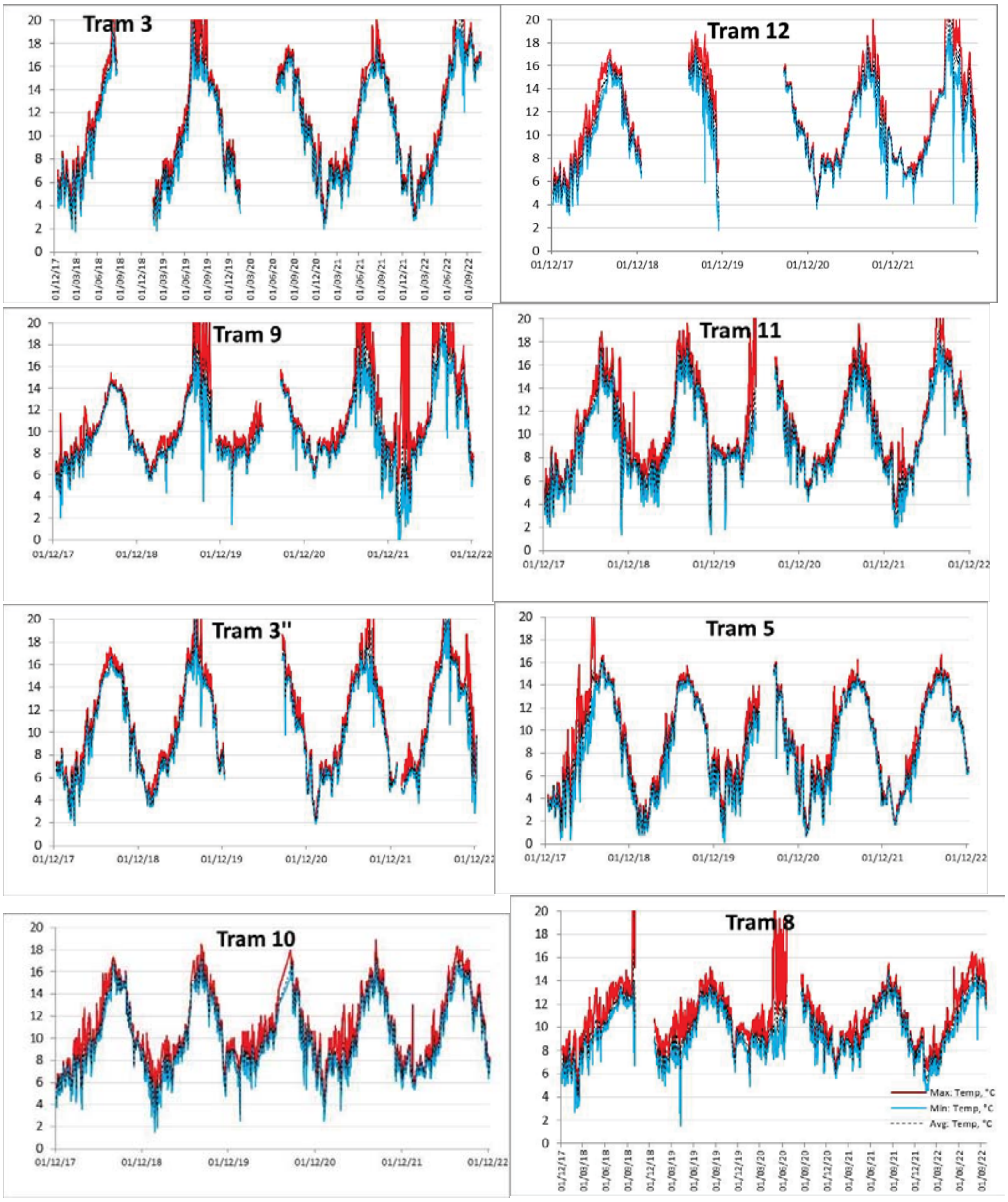

Tram 1
Tram 6

Fig7 (Cont.)


Tram 3
Tram 12
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Max. Temp, °C
Min. Temp, °C
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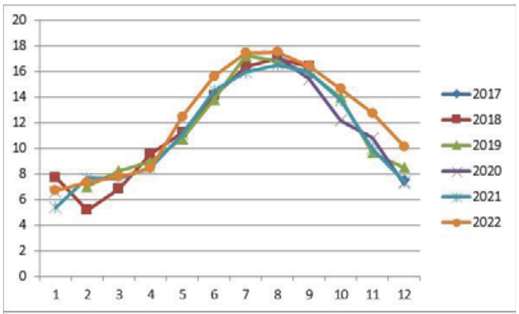
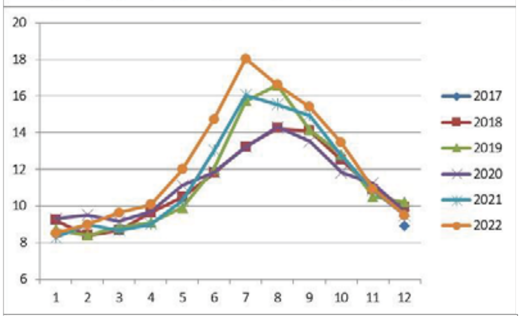
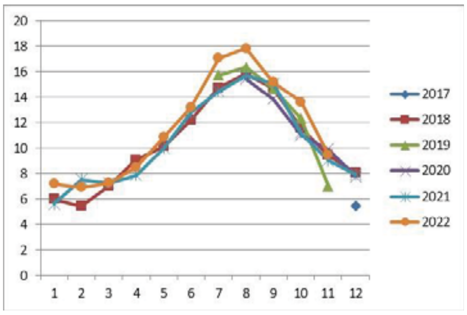
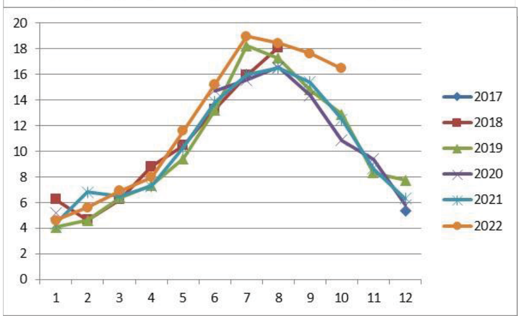
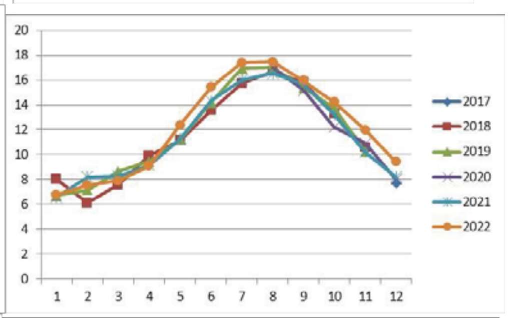


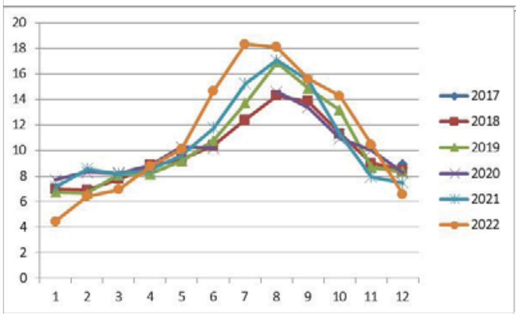
Fig 8: Mean monthly temperature (ºC) from 2017 to 2021. On the right are the streams with Triton, on the left without Triton, ordered by height a.s.l.

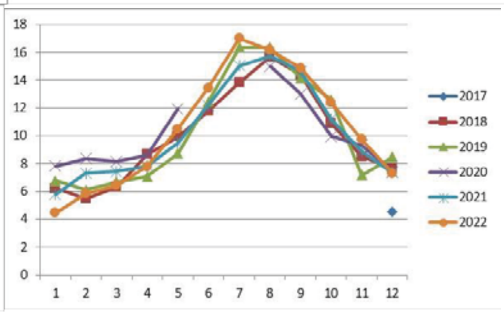


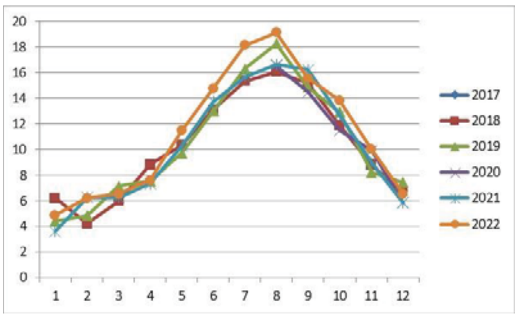












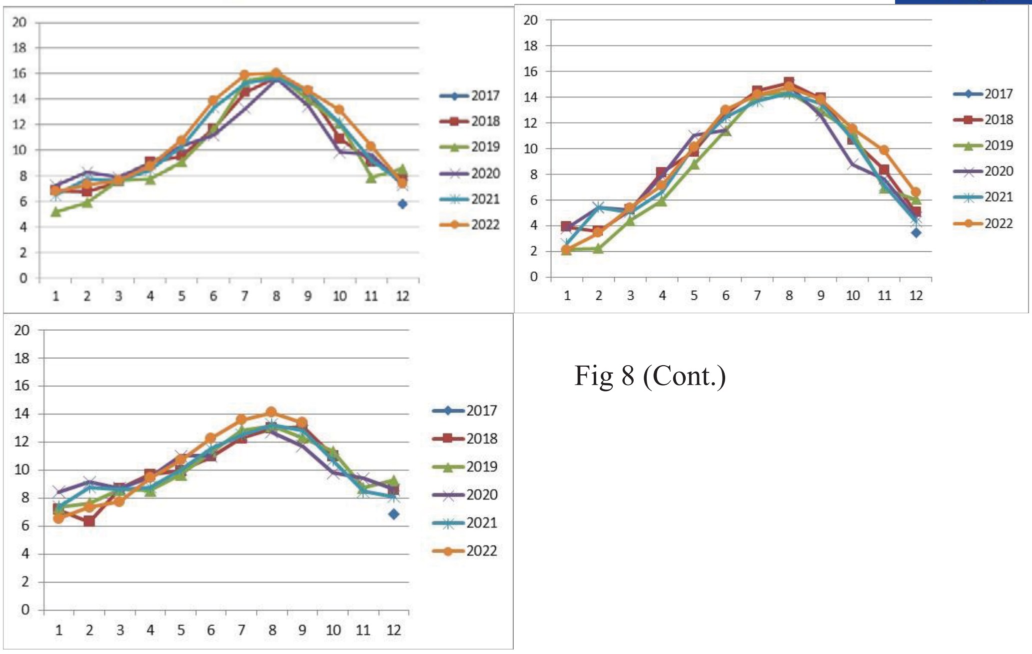


Fig 8 (Cont.)

Monitoring the impact of habitat improvement actions

Monitoring the impact of restoration river bed continuity

B6 Brook bridge installation

In the B6, the continuity of the stream bed was restored by installing a bridge and removing the material - soil and stones - that had accumulated to allow the forestry track to cross the ravine. This material created a discontinuity in the course of the water, altering the natural and progressive slope, as well as the continuity of the flow, as it infiltrated between the materials artificially placed to create the track.

The effect of the improvement works was to alter both the channel and the banks of the stream, with earth movements and soil loosening. These works release sediment into the stream and this could affect the river habitat by filling in the gaps. A sediment transport study was designed to find out if there was an increased release of sediment into the stream after the work was completed.

The sediment transport monitoring was designed with sediment traps spaced from the impact site (Fig. 10): under the runway and downstream to measure how far sediment transport occurs. Traps will also be placed upstream of the track to provide control samples. 3 sediment traps were placed at each site. Sediment transport was measured before and after the improvement works during the summer months, when flow is lower and it is therefore easier to measure the transport of materials, which is less quantitative. During the pre-construction period, traps were placed from 24 April to 10 December 2019. In the post-construction period, traps were placed from 3 May to the end of September 2021, months after the end of the action.

There is no change in the sediment transport due to the improvement of the B6 channel.
The amount of sediment transported is very variable, both in the different parts of the river and in time, as well as in the size of the sediment. No pattern can be observed for any of the factors involved (Fig. 12).

There are no differences between before and after the intervention, even the sediment amounts measured in the post-intervention period are slightly lower, although not significantly different.
There are no differences due to the distance from the work site. If there had been a release of sediment due to the work, we would expect to see more sediment in the water below the bridge.
There are also no differences between the sizes of sediment fractionation, with no change observed after the works, where a greater amount of fine sediment would be expected.
There is also no pattern of change in sediment transport according to the month studied, where we would expect less mobilisation in the summer months due to lower flow.

The movement of sediment in the river is therefore due to a factor unrelated to the improvement works. It is probably related to rainfall and changes in flow that mobilise sediments from the banks or drag them down the stream.

Fig. 9 Sediments transported -gr/day- in B6 of inorganic (blue) and organic matter (red), separated in 3 size classes: 2mm: greater than 2mm; 0.5mm: greater than 0.5mm and less than 2mm and T: less than 0.5mm; in localities: 1.- point above the track, 2.- point below the track, 3.- point downstream. Right column: pre-action samples, left column: post-action samples. The X indicates the lack of data due to the disappearance of the traps.

A1 Stream bridge installation

The work to restore the continuity of the river will inevitably involve the mobilisation of material that occupies the river bed, some of which will be carried away by the flow of water.
There will therefore be a significant influx of sediment downstream of the restoration site. In order to understand the dynamics of this material downstream, a follow-up study was carried out after completion of the work.
From the outset, it was observed that large amounts of sediment were indeed accumulating downstream of the bridge. However, this material only accumulated in the areas of the pools and not in the areas of the riffles. In other words, the areas where the water speed was slower were decantation areas.

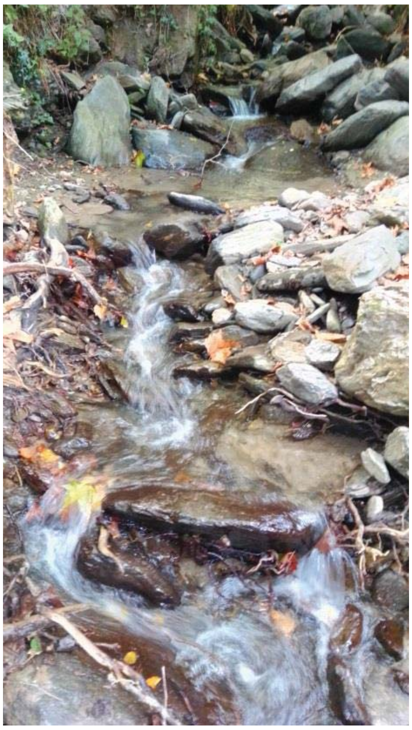


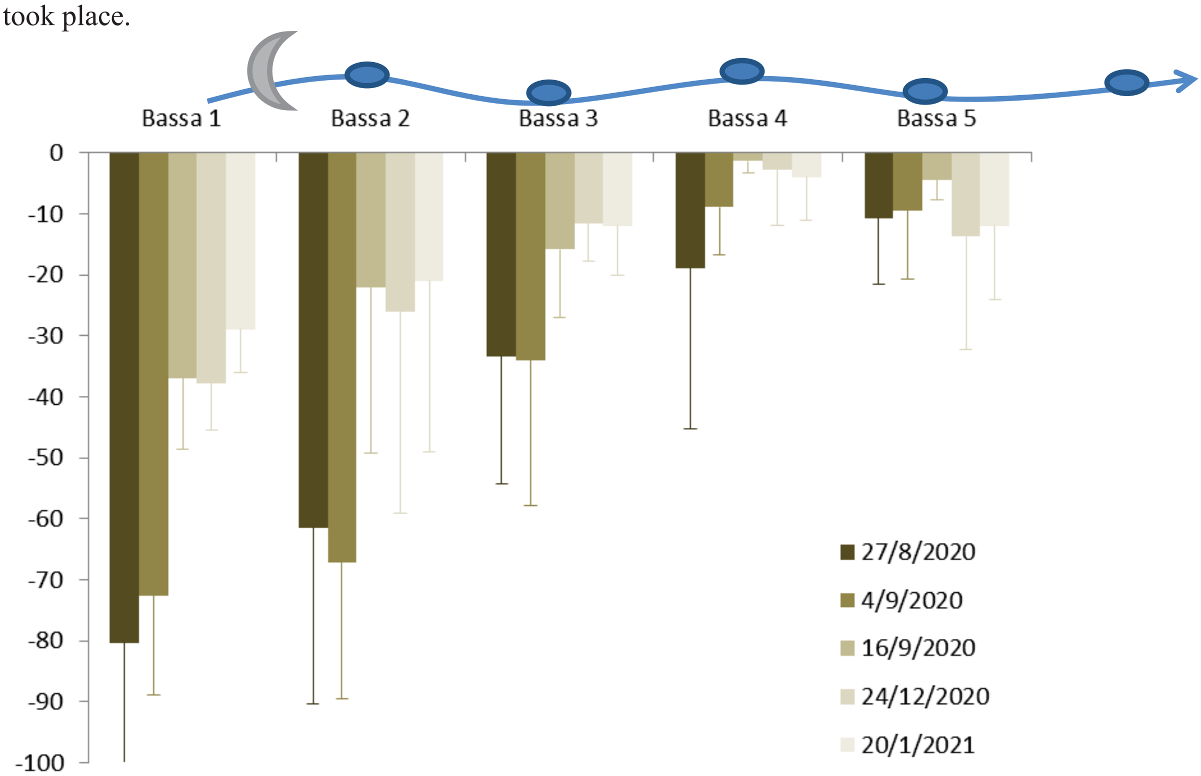
Fig10: Significant accumulations of fine sediments in pool 3 of the A1 stream (left) and areas of flowing water between pools 1 and 2 free of these sediments (right).

To determine the dynamics of these sediments, the amount of sediment accumulated in 5 pools downstream of the bridge was measured. The amount of accumulated sediment was measured as the proportion of the water column occupied by sediment: the thickness of the sediment layer in relation to the total depth of the pond. Along a transect in the widest part of the pond, the total depth of the pond and the depth of the sediment layer were measured every 10 cm.

Fig 11: Transect where sediment thickness is measured in Pool 2.

The results showed that the accumulation of sediments is more important the closer to the bridge and that these were mobilised quite slowly over time, they were quite persistent since 5 months after the first measurement the ponds still had a significant presence of sediments, although the amount in depth had decreased, the extent was quite similar. And they were flow dependent, plus there is more mobilisation, although it seems that a large flood is needed to make them clean. The circulating flow during the sampling period - between 27 August and 20 January 2021. Pools 4 and 5 - the furthest from the bridge - are slowing down sediment loss or even tending to increase sediment accumulation in recent days. They may be receiving sediment transported from upstream accumulation areas.
The accumulated material was very fine and formed a dense and compact layer, impenetrable to wildlife.

Fig 12: Percentage of pool depth occupied by sediment. Pool 1 is closest to the bridge where the restoration took place.



Restoration of natural riparian vegetation: effect on stream temperature

The presence of well-structured riparian vegetation prevents direct sunlight from falling on the streams and can limit the warming of the stream.

In the A2 stream, temperature sensors were installed in a section without vegetation cover and in another with vegetation cover to determine its effect on the temperature of the stream over a period of almost two years.

The results show little difference between the temperatures of the two sections, with monthly averages always less than 2 ºC different. In most months the temperature is lower in the shaded area, as expected. However, in the winter months it is the other way round, with the unshaded section being colder. This is probably because the vegetation prevents cold air from falling over the stream.

Fig 13: Boxplot of the monthly temperature differences between the Sun and Shade sensors (Calculated as Sun minus shade). Positive values indicate higher temperature in the unshaded section, negative values higher temperature in the shaded sections. The blue dotted lines indicate the months of January, the red ones the months of July.