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Video stations, a potential low-cost tool to monitoring invertebrates. A pilot study with Limnephilidae (Trichoptera)

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ABSTRACT. The aim of this study was to evaluate the performance of Underwater Video Stations (UVS) to detect caddisfly larvae (Trichoptera), estimate density in a lake, as well as to evaluate its effectiveness in tracking larvae. For this, were deployed UVS. Recording a total of 3120 minutes of video were analysed, of which 968 min were used for abundance analysis. Finally, caddisfly larvae were tracked using the Tracker software, which recorded the velocity of everyone in mm/s. This work successfully put into practice a novel sampling methodology for this insect group. The technique was implemented quickly, easily, and inexpensively and is highly scalable for the monitoring of aquatic invertebrates. Remote video stations are a potential tool for use in the field of population monitoring and studies of personality and behaviour in the natural habitat.
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KEY WORDS: conservation, environmental monitoring, insect larvae, littoral, underwater video.

Видеостанции, потенциальное дешевое устройство для мониторинга беспозвоночных. Пилотное исследование на ручейниках семейства Limnephilidae (Trichoptera)

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РЕЗЮМЕ. Цель работы — оценить использование подволных видеостанций (Underwater Video Stations, UVS) для выявления личинок ручейников (Trichoptera), определения их численности в озере, а также оценка эффективности отслеживания

личинок. Для этого были развернуты UVS. Проанализированы записи общей длительностью 3120 минут, из которых 968 минут были использованы для оценки численности. Наконец, личинки ручейников были отслежены с использованием программного обеспечения Tracker, которое записывало скорость каждого объекта в мм/с. Эта работа успешно внедряет в практику новую методологию учета этой группы насекомых. Техника запускается быстро, легко, недорога и удобна для мониторинга водных беспозвоночных. Удаленная видеостанция — потенциальное устройство для использования в области мониторинга популяций, индивидуальных наблюдений и исследований поведения в природных условиях.
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КЛЮЧЕВЫЕ СЛОВА: охрана, мониторинг окружающей среды, личинки насекомых, литораль, подводное видео.

Introduction

Underwater videos have won wide acceptance for the study of marine life in recent years (Mallet, Pelletier, 2014; Whitmarsh *et al*., 2016; 2018). Remote video techniques make it possible to collect information on how species relate to their habitat and to analyse their populations in a non-destructive way, including the patterns and processes that may drive them, such as feeding or reproduction (Trobiani *et al*., 2018, 2021; Irigoyen *et al*., 2018; Branconi *et al*., 2019; De Wysiecki *et al*., 2020). This technique is widely used for the analysis of richness, relative abundance, population monitoring, habitat preferences and fish behaviour in marine and freshwater bodies (Cappo *et al*., 2003; Sheehan *et al*., 2010; Ebner *et al*., 2014; 2016; King *et al*., 2017). Several authors have also begun to use them for invertebrate detection and quantification in marine systems (Carr, 2014; Merillet *et al*., 2018; Devine *et al*., 2019) and Chilean freshwater systems (Tilot *et al*., 2019). Other authors have used video to research freshwater invertebrates in laboratories in order to understand the behaviour and physiology of them (Urra, 2017; Näslund, 2021; Sclocco *et al*., 2021).

Aquatic macroinvertebrates or aquatic insects in general can be used as environmental bioindicators (Serna *et al*., 2015; Chikodzi *et al*., 2017; Brito *et al*., 2108; Krynak, Yates, 2018; Sreeja, 2018; Gadd *et al*., 2020). Benthic organisms play an important role in energy flow, nutrient cycling and connecting low trophic level organisms with high-ranking consumers in aquatic freshwater and marine ecosystems. Changes in the population of benthic organisms can be reflected in the community in general (Covich *et al*., 1999). The Trichoptera order is especially important due to its sensitivity to environmental change, and since 1988 Trichoptera larval distribution has been studied for evaluation of the trophic state of lakes. Several studies on the biogeographic, ecological and biological traits of Trichoptera detected the importance of global climate change in their populations, since they are very sensitive to high temperatures along elevation gradients, while other studies analysed the individual behaviour of organisms (Pello Isasi, 2020; Näslund, 2021; Sclocco, 2021). For this reason, we found it interesting to analyse the possibilities of using underwater video stations for monitoring the order Trichoptera.

The principal aim of this study was to evaluate the performance of UVS to detect caddisfly larvae (Trichoptera), estimate density in a lake, as well as to evaluate its effectiveness in tracking larvae for future behavioural or personality studies in the natural habitat.

Methods

Ethical Statement

Data from underwater videos were used in this study. Nevertheless, the protocols and procedures employed were reviewed and approved in accordance with relevant institutional and national guidelines for animal care. Animal care and use complied with National Park Administration (APN) and S.C

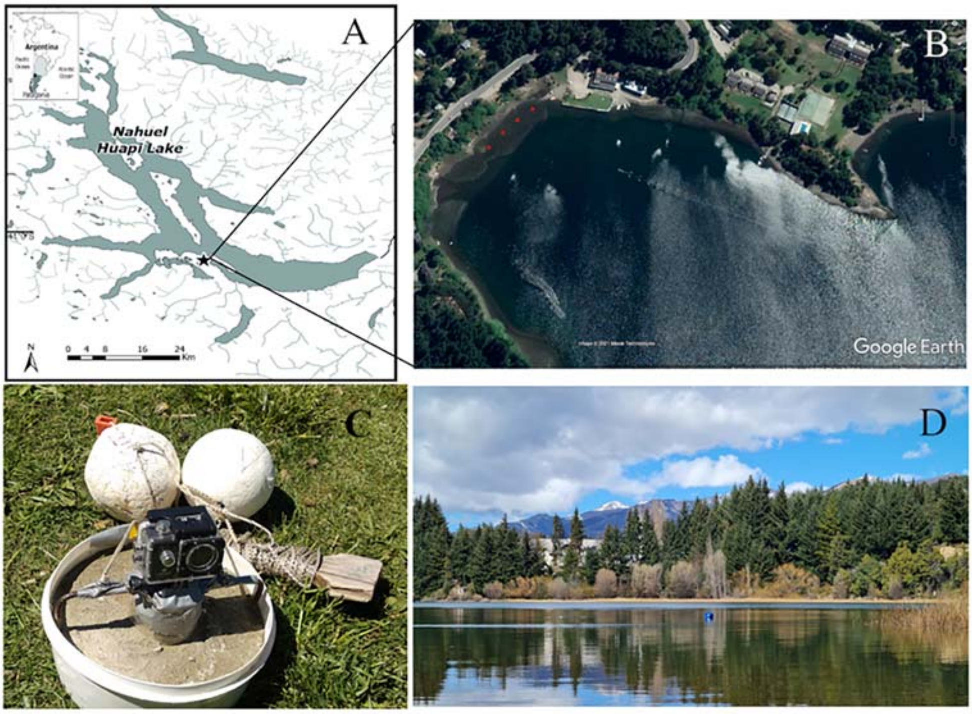

Fig. 1. A and B — study area on Brazo Campanario of Lake Nahuel Huapi, Patagonia, Argentina. The stars indicate sampling site; C — equipment for underwater video station (UVS); D — vegetated coast where the video stations were set up.

Рис. 1. A и B — область исследований в Brazo Campanario озера Nahuel Huapi, Патагония, Аргентина. Звездочками помечены места сборов; C — оборудования для подводной видеостанции (underwater video station, UVS); D — заросший берег, где была установлена видеостанция.

de Bariloche Council animal welfare laws, guidelines and policies. Permission to collect samples was given by Nahuel Huapi National Park (APN project n° 1173; IF-2018-61090117-APN-DRPN#APNAC; APN project n° 1740 IF-2021-66193320-APN-DRPN # APNAC) and S.C de Bariloche Council (note n° 412/SSMA/15).

Study area

The experiment was carried on in Brazo Campanario (41°03´S; 71°29´W; Fig. 1A, B, D), one of the seven branches of Nahuel Huapi lake, located within Nahuel Huapi National Park. This is Northern Patagonia's largest lake, it is situated at 765 m a.s.l. with a surface area of 557 km^2 and a maximum depth of 464 m (Díaz *et al*., 2007).

Underwater video stations

The UVS consists of a circular container of Polystyrene foam filled with concrete on which the camera (Ultra, Mod:70GPR0010N) is mounted with the original fastener, between 18 and 22 cm from the lake bottom (Fig. 1C). Four UVS were deployed at a depth of 0.6 m and deployment positions were recorded by GPS and marked at the site with anchors and buoys for precise repetition throughout the study. Using a 15-m-long tape measure from UVS, we placed a metre-by-metre ruler to calculate the range of the camera.

Underwater video stations (UVS) were deployed at the study site weekly during spring 2019. Each camera was left between 60 and 120 min to test the battery life of the cameras and also have the necessary hours of recording *sensu* Carr (2014). However, they were standardised to 60 min of analysis, beginning after 5–10 minutes of filming when water clarity returned to normal following UVS deployment. A total of 3120 minutes of video recordings were analysed, of which 968 min were divided into 1 min segments for analysis using the VLC (https://www.videolan.org) and Tracker 5.1 (https://physlets. org/tracker/) free software, to facilitate counting. In each one-minute segment the number of reeds (*juncus* sp.) (NR) from the picture frame, and for the Trichoptera an Nmax index (maximum abundance recorded) was used, to indicate the maximum number of trichopterans in a single video frame (Cappo, 2003; Smith *et al*., 2012). The Trichoptera index (Tindex) was generated considering the maximum number of caddisfly larvae present per number of reeds.

Larval Activity

To analyse the potential of this tool in behaviour and personality studies, we used the walking speed of each caddisfly larva to evaluate the feasibility of placing fixed video stations in lakes to measure larval activity. To have a known size reference at the same distance from the larvae a ruler was placed in front of the cameras at the beginning of filming. Width of the reeds was also measured. In this way we measure the components of the habitat and extrapolate with them the distance travelled by the larvae. Tracker is a free video analysis and modelling tool built on the Open-Source Physics (OSP) Java framework. Seven individuals in reeds were tagged and followed using this program minute by minute after 20 minutes of filming, for approximately 10 minutes, *sensu* Mundahl & Mundahl (2015). Using the scale tool and the Tracker software for analysis, the central point of the body of each larva was taken and its movement was observed to estimate the speed per second of the individuals. We represented the distance between the X and Y coordinates of each larva in two consecutive squares, and this corresponded to the average walking speed of the individual during the second before each frame analysed, *sensu* Sclocco *et al*. (2021).

Statistical analysis

Trichoptera abundance was converted to log(X+1) for statistical analysis. In this way, using the ANOVA Fisher test, we were able to see if differences were observed in the abundance values Nmax (Nmax is the more utilized index for analysing the abundance of video stations) and Tindex throughout the spring of the evaluation.

Results

Abundance of caddisfly

We tested one of the cheapest models' market cameras in the market (Ultra, Mod: 70GPR0010N) which cost around 29 US dollars. The Ultra cameras film in Full HD 1080 hp, have an angle of 140 degrees and the battery life is 1.5 hours. The focal distance camera is 0.5 m from the lens, so we calculated the area range of the camera from that distance. The maximum linear range distance on days with the best visibility was 6 m. Using only a quarter of the total linear distance (1.5 m) one and a half metres of the camera focus, the area sampled is approximately 5.5 square metres.

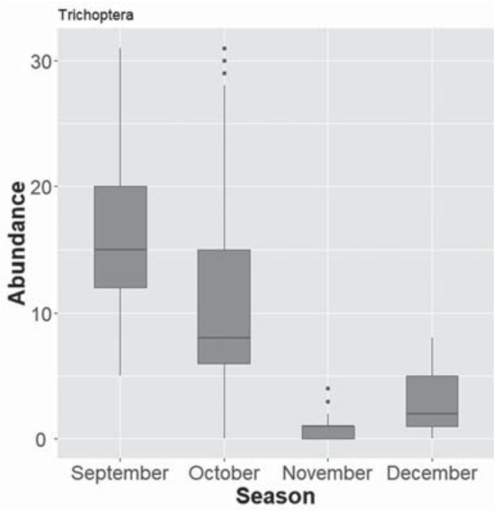

Fig. 2. Caddisfly larvae abundance during the sampling months.
Рис. 2. Численность личинок ручейников во время исследований, по месяцам.

The video camera system not only allowed us to identify but also proved to be very effective at recording differences in the known abundance over time. Through our imaging and identification of the collected specimens in the laboratory, the caddisfly larvae were identified as belonging to the Limnephilidae family. Although individuals were observed in the substrate, for the abundance analysis we considered only individuals on the reeds within 5.5 square metres. The highest Nmax value reached was 31, the maximum Tindex was 0.6 and the average Tindex was 0.8. In most deployments the maximum value was observed during the first 30 minutes of recording. We observed significant differences between the months analysed (ANOVA $F=319.1$ $p<2$ e-16): Nmax decreased as spring progressed (Fig. 2).

Larval activity

Using this simple methodology with a free program we were able to obtain the speed of movement of the larvae on the reeds. We observed an average speed being between 0.3- and 8.53-mm s^{-1} and the maximum speed of 19.8 mm s^{-1}.and (Table 1, Video S1).

Table 1. The activity of reeds caddisfly larvae. Tracked time t (s) and speed v (mm/s).
Таблица 1. Активность прибрежных личинок ручейников. Время отслеживания (сек) и скорость (мм/сек).

	A		B		C		D	
	t	v	t	v	t	v	t	v
Max	597.2	19.0	291.8	7.4	328.2	16.6	172.8	19.8
Min	0.0	0.0	0.0	0.0	237.5	0.0	140.1	0.0
Average	298.8	1.1	146.0	0.3	282.9	2.1	156.4	8.5
Movements quantity	1440	1438	703	701	220	218	80	78
	E		F		G			
	t	v	t	v	t	v		
Max	89.9	18.2	597.2	10.1	597.2	8.8		
Min	0.0	0.0	0.0	0.0	150.0	0.0		
Average	42.0	3.4	298.0	0.4	378.0	1.4		
Movements quantity	181	173	1440	1438	1035	1021		

Discussion

As far as we know, this work is the first study that evaluates the use of UVS underwater stations for the detection, abundance estimation and mobility of Trichoptera of Patagonia (Argentina). The results reported here suggest that using cheap cameras, it is possible to detect and estimate the abundance, as we did to Limnephilidae (Trichoptera) and even note changes in abundance throughout the seasons. The maximum number of individuals registered in each recording was reached in the first 30 minutes, indicating that a total deployment time per station of 60 minutes was sufficient. The battery of the cameras was not a limitation in this work and in fact they lasted longer at least 5-10 minutes more than indicated by the manufacturer. In addition, in light of these results, shorter deployment times could be planned in the future, reducing field work and video processing costs. Extraction methods are the most widely used in insect studies and have been a valuable sampling method for over half a century. These are the best methods for identifying insects individually, but underwater videos constitute a novel technique that is becoming increasingly popular for sampling a variety of clear aquatic environments (Willis, Babcock, 2000; Moore *et al*., 2003; Cappo *et al*., 2007; Ellender *et al*., 2012). For the identification of individuals, we tried to use the digital zoom on the images taken from video, but a microscope was necessary for identification to family level.

Arthropods constitute an important component of animal biodiversity on Earth and form part of many trophic levels, which makes them highly relevant for ecological studies (Minelli *et al*., 2013). The Trichoptera have been studied worldwide and until now the main method used was extractive; however, for the purposes of ecological management, conservation, and research, extractive sampling techniques are unethical or counterproductive (Trobbiani *et al*., 2021). For this reason, this work aims to provide an effective tool, once individuals have been identified, for monitoring populations of this order without requiring the extraction of individuals even during rainy days. During the one-off follow-up of caddisfly larvae, we were not able to use the automatic tracking of the programme. This was due, firstly, to the fact that the individuals were camouflaged in the environment, and secondly, to the fact that the number of large particles circulating interfered with the analysis. For this reason, all individuals were tracked manually, taking the centre of the body as the point to follow. Although this work was tedious, it enabled us to observe the behaviour of the individuals in their natural habitat without resorting to extraction or manipulation that could alter their behaviour.

Conclusion

Our findings advance the emerging literature on underwater videos as a tool in freshwater invertebrate monitoring. We tested the efficacy of the cheap camera for abundance and movement of trichoptera larvae. The results presented here show that this technique is a suitable tool for population surveys and monitoring of caddisfly larvae, which are of ecological relevance in aquatic environments. It should be noted that remote video stations could also be useful in the field of behaviour and personality studies of these organisms, as no disturbances are generated in the environment and the inadvertent removal of other species is prevented. In compromised areas this type of technique is essential to avoid contributing to their degradation.

Supplementary data. The following Supplementary Data are available online.

Video S1. Tracking of caddisfly larvae.

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Conflict of interest. The authors declare that they have no conflict of interest.

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