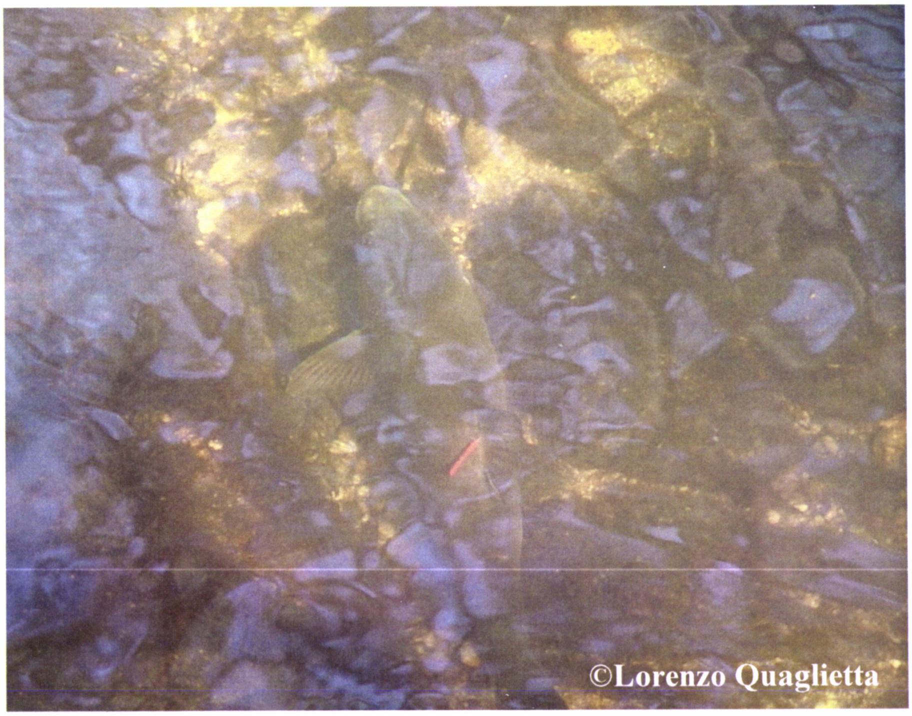
UNIVERSIDADE DE ÉVORA

Dárcio Filipe Jacob de Sousa

Padrões de deslocação e actividade diária do barbo-comum (*Barbus bocagei*, Steindachner 1865), num curso de água Mediterrânico de tipo intermitente.



Orientador: Prof. Doutora Maria Ilhéu

Dissertação submetida à Universidade de Évora
para obtenção do grau de Mestre em Biologia da Conservação

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Nota prévia

A dissertação apresentada está estruturada de acordo com o formato usualmente utilizado no âmbito do Mestrado em Biologia da Conservação da Universidade de Évora.

Nos capítulos 1 e 2 é apresentado o Resumo e o Abstract, respectivamente, do trabalho desenvolvido. No capítulo 3 é apresentada uma breve introdução onde se descreve a espécie em estudo, as principais componentes do trabalho, bem como os objectivos gerais.

No capítulo 4 encontra-se o principal corpo da dissertação, sendo este constituído por um "artigo científico".

No capítulo 5 apresentam-se as considerações finais, com algumas conclusões do estudo, demonstrando as questões centrais inerentes à conservação das populações de *Barbus bocagei*.

Agradecimentos

Gostaria de agradecer a todos que de alguma forma contribuíram para a realização desta dissertação.

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1. Resumo

Treze indivíduos da espécie *Barbus bocagei* (Steindachner 1865) foram marcados com transmissores de rádio, implantados cirurgicamente, e monitorizados num troço da rede hídrica da ribeira de Valverde (Bacia Hidrográfica do rio Sado, Portugal), entre 12 de Março e 8 de Agosto, de 2009, com o objectivo de estudar os padrões de movimento e actividade desta espécie. A monitorização foi efectuada por telemetria baseada na técnica de "homing" a partir das margens, tendo-se realizado ciclos de localizações diárias e ao longo de 24 horas.

Durante o período de estudo, os barbos monitorizados apresentaram um home-range entre 0.5 e 3,2 km ocupando tanto troços da ribeira como a albufeira da Tourega. As áreas vitais ocupadas na ribeira foram superiores às ocupadas na albufeira. Entre Março e o início de Abril apresentaram grande mobilidade, ocupando as zonas mais a montante da área de estudo, onde se observa maior disponibilidade de habitats reófilos, com potencial reprodutivo. De forma geral, verificou-se um decréscimo da área vital e dispersão dos barbos ao longo do período de estudo, associado à diminuição da profundidade e velocidade da corrente do curso de água. No final de Maio os indivíduos migraram para a albufeira, onde permaneceram durante o Verão. Relativamente à actividade diária, os resultados demonstraram que, os períodos de maior actividade dos barbos ocorrem ao amanhecer e ao anoitecer. Nos períodos de menor actividade, os indivíduos ocorreram em habitats menos profundos mas com elevada percentagem de refúgios.

Os resultados mostram que a disponibilidade de água na ribeira influencia fortemente a dispersão dos barbos e que a albufeira assume um papel determinante como refúgio estival para a espécie. Levanta-se, ainda, a hipótese que a presença de lontra (*Lutra lutra*) na área de estudo seja um factor determinante no padrão de comportamento dos barbos, devido às condições de habitat enquadrarem uma forte interação presa-predador. Os barbos apresentaram grandes áreas vitais e elevada dispersão na área de estudo enfatizando a necessidade de se desenvolver uma estratégia de conservação da espécie à escala da bacia hidrográfica, com particular atenção a cenários onde se verificam constrangimentos à deslocação dos indivíduos.

Palavras-chave: *Barbus*, peixes dulçaquicolas, telemetria, actividade diária, área vital, mobilidade.

2. Abstract

Thirteen individuals of *Barbus bocagei* (Steindachner 1865) were tagged with radio transmitters surgically implanted and tracked in Valverde stream (Sado River Basin, Portugal) between March 12th and August 8th, of 2009, to study their movement and activity patterns. The monitoring was carried out by telemetry, using homing technique from the banks, on daily fish locations basis and on several 24 hour cycles.

The barbel's home-range ranged from 0.5 to 3.2 km, occurring both the stream sector and the reservoir during the study period. Home-range occupied within the stream was higher than those occupied in the reservoir. Between March and early April, barbels showed great mobility, using the areas further upstream of the study area, with higher availability of reophilic habitats, suitable for spawning. Barbels home-range and dispersal decreased with stream water depth and current velocity which occurred, along the study period. In late May the individuals migrated to the reservoir, where they remained during the summer. The results showed that, in general, the periods of higher activity of fish are observed at dawn and dusk. During the resting periods, barbels tend to use shallower habitats but with percentages of refuges.

The results point out the importance of the reservoir as summer refugia for barbels that the water availability in the stream strongly influences the dispersion of fish. The pattern of barbel's movements and activity seems to be strongly influenced by the presence of otter (*Lutra lutra*) in the study area as habitat features promotes a strong prey-predator interaction. Barbels present large home-ranges and high dispersal movements along the river network which emphasize the requirement of a Fish Conservation Strategy at the river basin scale.

Keywords: *Barbus*, freshwater fish, radio tracking, diel activity, home-range, mobility.

3. Introdução

Os comportamentos das populações associados com as migrações de peixes de ecossistemas aquáticos dulçaquicolas estão entre os mecanismos mais mal entendidos de dispersão de ecossistemas de águas doces temperadas (Nunn *et al.*, 2010). Assim, o aumento da compreensão das migrações nos últimos anos levou a um aumento das preocupações sobre os possíveis impactos das barreiras sobre a distribuição, estrutura populacional, o sucesso da desova e recrutamento de muitas espécies (Ponton *et al.*, 2000; Quintella *et al.*, 2004; Almeida *et al.*, 2005; Nunn *et al.*, 2010). Na verdade, as barreiras de migração são agora reconhecidos como uma das principais ameaças para peixes de água doce a nível mundial (Lucas & Baras, 2001).

A estimativa de mobilidade e a actividade de peixes, embora seja difícil de obter, são aspectos importantes da ecologia dos mesmos (Cooke *et al.*, 2001), sendo estes fenómenos de mobilidade e de dispersão (mobilidade diária, home-range, migrações reprodutivas e comportamento de homing), bem como as suas variações durante o ciclo anual factores importantes na biologia das populações de peixes (Ovidio, 1999).

Os parâmetros físicos (temperatura da água, fluxo no afluente, precipitação, etc) funcionam como mecanismos de partida para os ciclos de reprodução e sua influência na duração das migrações de desova (Arnekleiv & Kraabøl, 1996; Piecuch *et al.*, 2007).

Muitos autores têm estudado as migrações de desova utilizando rádio telemetria (Gerlier & Roche, 1998; Monet & Soares, 2001; Aarestrup *et al.*, 2002; Ovidio *et al.*, 2002; Ovidio & Philippart, 2002; Piecuch *et al.*, 2007). O uso de telemetria para estudos em ambientes dulçaquicolas começou na década de 1950 (Rogers, 2007), com o intuito de estudar o comportamento e a mobilidade de diversas espécies da fauna silvestre, no seu habitat natural (Pinheiro *et al.*, 2004). Esta técnica baseia-se na detecção remota de um sinal, emitido através de transmissores colocados nos animais a monitorizar (Kenward, 2001; Pinheiro *et al.*, 2004). Desde a sua introdução, a telemetria tem sido amplamente utilizada para monitorizar as actividades e os movimentos dos peixes em diversas partes do mundo (Baras & Cherry, 1990) tornando-se, ao longo das últimas décadas, a técnica mais aplicada para seguir peixes migradores (p.e. Travade *et al.*, 1989; Chanseau *et al.*, 1999; Travade & Larinier, 2002; Pinheiro *et al.*, 2004). A Telemetria representa, hoje, um conjunto de metodologias que permitem melhorar o nosso conhecimento e entendimento da forma como os animais selvagens ou em cativeiro reagem e se adaptam ao seu ambiente (Baras & Lagardère, 1995; Baras, 1998).

Dadas as restrições ambientais sobre as metodologias de amostragem (pesca eléctrica ou observação directa), a telemetria é um método adequado de investigação para a caracterização do conjunto dos parâmetros da mobilidade e da dispersão, principalmente em indivíduos adultos (Ovidio, 1999).

Durante a última década tem havido um interesse crescente na forma como os peixes de água doce seleccionam o seu habitat, tanto para avaliar as preferências e os limites de tolerância da espécie, como para modelar o impacto das alterações de habitat sobre a sua capacidade de responder a essas alterações (Baras, 1997). As áreas de distribuição são fundamentais para compreender a diversidade de habitats, feitos da fragmentação e conservação, sendo que a distância que um organismo percorre fornece informação sobre a história de vida, a genética e as interacções sobre outros organismos (Woolnough *et al.*, 2009). A teoria actual sugere que a área de distribuição é definida pelo tamanho do corpo dos indivíduos (Woolnough *et al.*, 2009). Por estas razões, o posicionamento diário dos peixes equipados com dispositivos de telemetria, juntamente com acompanhamento contínuo ao longo de alguns ciclos de 24 horas, pode dar uma imagem representativa da forma como eles utilizam o espaço envolvente (Baras, 1998).

A ribeira de Valverde está inserida na Bacia Hidrográfica do Sado, pertencente à região mediterrânica. Este sistema dulçaquicola apresenta importantes comunidades piscícolas, com algumas espécies, entre elas o barbo comum.

O barbo-comum (*Barbus bocagei,* Steindachner 1865), também denominado de barbo-do-norte, é um ciprinídeo nativo da Península Ibérica (Ferreira *et al.*, 1999; Doadrio, 2001; Pinheiro *et al.*, 2004), com uma distribuição muito vasta, ocupando a quase totalidade das Bacias Hidrográficas de Portugal Continental, com excepção das bacias dos Rios Guadiana, Mira e das Ribeiras do Algarve (Pinheiro *et al.*, 2004). É de referir ainda, que é uma espécie que se encontra bem adaptada, ocorrendo em muitas albufeiras do nosso país (Ferreira *et al.*, 1999).

É uma espécie reófila potamodroma, que pode atingir dimensões consideráveis (Ferreira *et al.*, 1999) e ocorre num largo espectro de habitats tanto em sistemas lóticos como lênticos. Não obstante, tende a seleccionar habitats com condições tão próximas às suas preferências quanto possível, seja qual for a distância entre eles (De Vocht *et al.*, 2005). Tem preferência por habitats com corrente fraca ou moderada (pools), evitando águas com temperaturas baixas, e utilizam as zonas com detritos lenhosos ou substratos rochosos como abrigo (Almaça, 1996). Assim a disponibilidade de habitats com valor de abrigo pode condicionar o grau de movimentação dos peixes (Ilhéu, 2004).

B. bocagei é uma espécie que ostenta um comportamento alimentar bentónico, apresentando uma alimentação omnívora (Almaça, 1996; Ferreira *et al.*, 1999) e oportunista (Almaça, 1996), recorrendo, por vezes, às componentes mais abundantes e acessíveis dos cursos de água, nomeadamente material vegetal (macrófitos aquáticos e algas filamentosas), insectos (dípteros, efemerópteros, plecópteros), crustáceos, podendo também consumir detritos em suspensão na água (Almaça, 1996). Pode ainda alimentar-se de larvas de *Ephemeroptera*, *Trichoptera*, *Coleoptera* e *Mollusca* (Mateus, dados não publicados).

A época de reprodução ocorre usualmente entre Abril a Junho, efectuando migrações potádromas para os locais propícios para a desova, que são zonas pouco profundas e com uma velocidade de corrente considerável, com substrato de areia e cascalho e elevada turbulência, ou seja, bastante oxigenada (Pouilly & Souchon, 1994; Martinez-Capel & Garcia de Jalon, 2002; Ilhéu, 2004; Pinheiro *et al.*, 2004). Estas migrações reprodutoras para montante têm sido observadas nos rios e nos tributários das albufeiras (Ferreira *et al.*, 1999; Rodriguez-Ruiz & Granado-Lorencio, 1992).

No livro vermelho dos Vertebrados de Portugal, o barbo-comum tem estatuto Pouco Preocupante (LC), mas, apesar de ser um *taxon* abundante, nos últimos anos tem ocorrido uma regressão nos seus efectivos populacionais, devido a um conjunto de factores como a deterioração de habitats, a introdução de espécies exóticas e a pressão piscícola (e.g. Almaça, 1983, 1995; Godinho & Ferreira, 1998; Collares-Pereira *et al.*, 2000; Cabral *et al.*, 2006). A degradação do habitat será possivelmente o principal factor de ameaça da espécie, derivando essencialmente do efeito barreira das obras hidráulicas, com a consequente fragmentação da malha habitacional, da alteração do regime de caudais (reduzindo o escoamento), das captações de água e da extracção de inertes (Bernardo *et al.*, 2003). A introdução de algumas espécies exóticas poderá ser igualmente responsável por algum declínio da população de *B. bocagei* na Península Ibérica, sobretudo devido à competição pelos recursos (alimento, habitat e locais de refúgio), mas também podem resultar da predação que é exercida, particularmente sobre as fases juvenis, por algumas das espécies introduzidas como o achigã (*Micropterus salmoides*), o lúcio (*Esox lucius*) e a lucioperca (*Sander lucioperca*) (Almaça, 1996). A pressão piscícola é uma consequência do barbo-comum ser uma espécie com elevado interesse do ponto de vista desportivo e mesmo alimentar. A utilização frequente de métodos de captura ilícitos em Portugal, sobretudo o envenenamento com substâncias tóxicas e a utilização de explosivos e de artes de pesca ilegais, também é um factor importante no decréscimo populacional de diversas espécies piscícolas portuguesas (Bernardo *et al.*, 2003). Aliado a estes factores podem ainda ocorrer acontecimentos ambientais estocásticos, típicos dos cursos Mediterrânicos que podem produzir mudanças nas ictiocenoses (Bernardo *et al.*, 2003).

4. Objectivos

A variabilidade hidrológica das regiões típicas mediterrânicas determinam as formas e ciclos de vida dos organismos aquáticos, bem como os processos ecológicos associados. Estes sistemas apresentam elevada variação inter-anual de pluviosidade, o que provoca alterações drásticas nos sistemas dulçaquicolas. A ictiofauna proveniente destes ecossistemas altamente dinâmicos sobrevive frequentemente em situações que alternam entre situações de enxurrada e cheias e longos períodos secos, resultando num padrão de grande variabilidade na disponibilidade de água. Desta forma a conectividade longitudinal dos cursos de água de carácter temporário assume um papel vital para o sucesso das migrações reprodutivas e consequente recrutamento dessas populações.

Portanto, a identificação do momento em que ocorre a migração, o comportamento do movimento dos peixes e actividade, assim como os factores ambientais que determinam esses movimentos ascendentes e descendentes são cruciais para compreender a estrutura da população, sucesso da postura e recrutamento da espécie e da viabilidade das populações de barbos em ribeiras de tipo mediterrânico.

O principal objectivo deste estudo é analisar o movimento e a actividade dos barbos (*Barbus bocagei,* Steindachner 1865) numa ribeira mediterrânica de tipo intermitente localizada a montante de uma pequena albufeira. Além disso, a relação entre os movimentos dos peixes e a dinâmica ambiental da ribeira é também avaliada. Desta forma compreender o papel da albufeira para as comunidades piscícolas é também um objectivo relevante. Este estudo faz parte de um estudo mais amplo sobre o papel das albufeiras na estrutura das comunidades e influência do escoamento sobre a dinâmica populacional das comunidades piscícolas.

5. **Artigo científico** – Padrões de deslocação e actividade diária do barbo-comum (*Barbus bocagei*, Steindachner 1865) num curso de água Mediterrânico de tipo intermitente.

Patterns of movement and diel activity of Iberian Barbel (*Barbus bocagei*, Steindachner 1865) in a temporary Mediterranean stream.

Dárcio Sousa, Lorenzo Quaglietta and Maria Ilhéu

Abstract

Thirteen individuals of *Barbus bocagei* (Steindachner 1865) were tagged with radio transmitters surgically implanted and tracked in Valverde stream (Sado River Basin, Portugal) between March 12th and August 8th, of 2009, to study their movement and activity patterns. The monitoring was carried out by telemetry, using homing technique from the banks, on daily fish locations basis and on several 24 hour cycles.

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movements along the river network which emphasize the requirement of a Fish Conservation Strategy at the river basin scale.

Keywords: *Barbus*, freshwater fish, radio tracking, diel activity, home-range, mobility.

Introduction

The hydrological variability of the typical Mediterranean regions determines the forms and life cycles of aquatic organisms and the ecological processes involved. Mainly in the southern regions, freshwater streams present both high interannual and seasonal variation of rainfall, and consequently of runoff, causing dramatic changes in the environmental conditions. The biota of these intermittent streams has evolved facing highly dynamics environmental contexts, both spatially and temporally. In intermittent streams, as those present in the south of the Iberian Peninsula, the fish fauna often survive in extreme conditions, facing seasonal dramatic environmental changes; lotic *vs* lentic and very high (from late Autumn to early Spring) *vs* low water availability (Summer), with intermediate periods that are crucial for the investment in recruitment and growth (Mathews, 1998; Ferreira *et al.*, 2007). During the dry period, the aquatic ecosystem contract and fish fauna is frequently confined to isolated pools, varying in size according to their position on the river watershed; larger pools tend to persist in downstream sectors, often presenting less harsh environmental conditions and larger populations (Mathews, 1998; Magoulick, 2000; Magalhães *et al.*, 2002a; Ilhéu, 2004). These pools are fundamental as refugia (*sensu* Ims & Yoccoz, 1997), being the ones from where the metapopulations re-colonize the stream network during the expansion phase, when stream connectivity is re-establish (Magalhães *et al.*, 2002b; Bernardo *et al.*, 2003). Under these conditions, long-lived fishes, as barbels, tend to present migration behaviors' as an ecological strategy to cope with seasonal flow and habitat variability (e.g. Baras & Cherry 1990; Baras, 1995; Lucas & Batley, 1996; Lucas & Frear, 1997; Ilhéu, 2004).

The population behaviour associated with fish migrations is amongst the most poorly-understood dispersal mechanisms in freshwater ecosystems (Nunn *et al.*, 2010). The increase in understanding of migrations in recent years has led to concerns over the possible impacts of barriers on the distribution, population structures, spawning success and recruitment of many species (Ponton *et al.*, 2000; Quintella *et al.*, 2004; Almeida *et al.*, 2005; Nunn *et al.*, 2010).

Radio-telemetry as been used to monitor the activities and movements of fishes throughout North America and other parts of the world (e.g Travade *et al.*, 1989; Baras & Cherry, 1990; Chanseau *et al.*, 1999; Travade & Larinier, 2002; Pinheiro *et al.*, 2004), and it seems to be quite suitable to study fish spawning migrations (e.g. Gerlier & Roche, 1998; Monet & Soares, 2001; Aarestrup *et al.*, 2002; Ovidio *et al.*, 2002; Ovidio & Philippart, 2002; Piechch *et al.*, 2007). Biotelemetry nowadays represents a performing set of methodologies enabling to improve our knowledge and understanding of the way wild or captive animals react and adapt to their environment (Baras & Lagardère, 1995; Baras, 1998). Given the environmental constraints on the sampling methodology (electrofishing or direct observation), telemetry is a suitable method of investigation for the characterization of all the parameters of mobility and dispersal, especially in adults (Ovidio, 1999). The estimate of movements and activity (e.g. daily mobility, home-range, reproductive migrations, and its variations along the annual cycle) are important aspects of freshwater fish ecology (Ovidio, 1999; Cooke *et al.*, 2001) being essential knowledge to support fish fauna conservation programs in Mediterranean-type streams.

The freshwater fish fauna of the southern Iberian Peninsula present a high number of endemism with considerable conservation value, nevertheless many species are listed in the Portuguese Red Data Book (Cabral *et al.*, 2006) and in international conventions (such as Habitats Directive, 92/43/EEC). The Iberian Barbel (*Barbus bocagei*, Steindachner 1865) is a cyprinid native to this region, with a very wide distribution, occupying almost all mainland Portuguese basins, with the exception of Guadiana, Mira and Algarve catchments (Doadrio, 2001; Cabral *et al.*, 2006). Despite presenting a status of Least Concern (LC, Cabral *et al.*, 2006) and being an relatively abundant taxon, in recent years has suffered a regression in their populations, due to different factors, namely damming, water abstraction, sand and gravel extraction, eutrophication, habitat degradation in general, and the introduction of exotic species (e.g. Almaça, 1983, 1995; Godinho & Ferreira, 1998; Collares-Pereira *et al.*, 2000; Cabral *et al.*, 2006). Habitat loss is probably the major factor threatening fish fauna, and it is essentially derived from the barrier effect of hydraulic works, with the consequent fragmentation of the mesh housing, changes in the flow regime (reducing runoff), water abstraction and aggregate extraction (Bernardo *et al.*, 2003).

The Iberian barbel is a rheophilic and potamodromous species, which occurs in a wide range of habitats in both lotic and lentic systems, being a species that shows great adaptability to different systems and may reach considerable size (Almaça, 1996; Ferreira *et al.*, 1999). Nevertheless, it tends to select spawning habitats in water courses with particular physical features; shallow areas and with a considerable current speed, with sand and gravel substrate and high turbulence, thus well oxygenated (Pouilly & Souchon, 1994; Martinez-Capel & Garcia de Jalon, 2002; Ilhéu, 2004; Pinheiro *et al.*, 2004). In order to reach the spawning grounds, adults barbels may migrate several kilometers, depending on flow conditions and habitat patchiness as well on the distance from the re-colonizatuon meta-populations (e.g. Baras, 1993; Lucas & Frear, 1997; Ilhéu, 2004), which may be located in reservoirs with good conditions for fish, including tributaries connectivity (Encina & Granado-Lorencio, 1991, 1997; Rodriguez-Ruiz & Granado-Lorencio, 1992; Ferreira *et al.*, 1999). Therefore, the identification of migration timming, fish movement behavior and activity and the environmental factors that determine up and downstream movements are crucial to understand the population structures, spawning success and recruitment of this species and the viability of barbel's population in Mediterranean-type streams subjected to increasingly damming and habitat modification.

The main purpose of this study is to analyze barbel's (*Barbus bocagei*) movements behavior and activity in an intermittent Mediterranean-type stream located upstream a small reservoir. Moreover, the relationship between fish movements and stream environmental dynamics is also assessed. This study is part of a larger program studying the role of reservoirs on fish assemblages structure and the influence of stream flow on fish population dynamics.

Methods

Study site

The study was carried out in the Valverde stream (Sado river basin), between Tourega reservoir (38 ° 30 '19.63"N, 8 ° 01' 54.19"W) and Valverde locality (38 ° 31 ' 57.85"N, 8 ° 01 '15.53"W), located in the southern of Portugal. This stream is an intermittent watercourse of Mediterranean type, for which precipitation strongly determines the distribution of annual flow, being, frequently, extremely low or zero during the summer months (June to September). The monthly precipitation observed for the period of study (March to August 2009) ranged from 28.9 mm (April) to 0.4mm (August). It was a year with a mean precipitation below the average of the last 30 years, with the exception of January (Figure 1). This fact had a great impact on the stream longitudinal connectivity, which in regular years takes place in October/November, but in study year occurred only in February. Moreover the flow stream stopped earlier and the connectivity between the reservoir and stream was lost by the end of May, when the water course began to dry up. Average daily water temperatures was ranged from 16.0 ° C (March) to 29 ° C (August) (CGE, unpublished data).

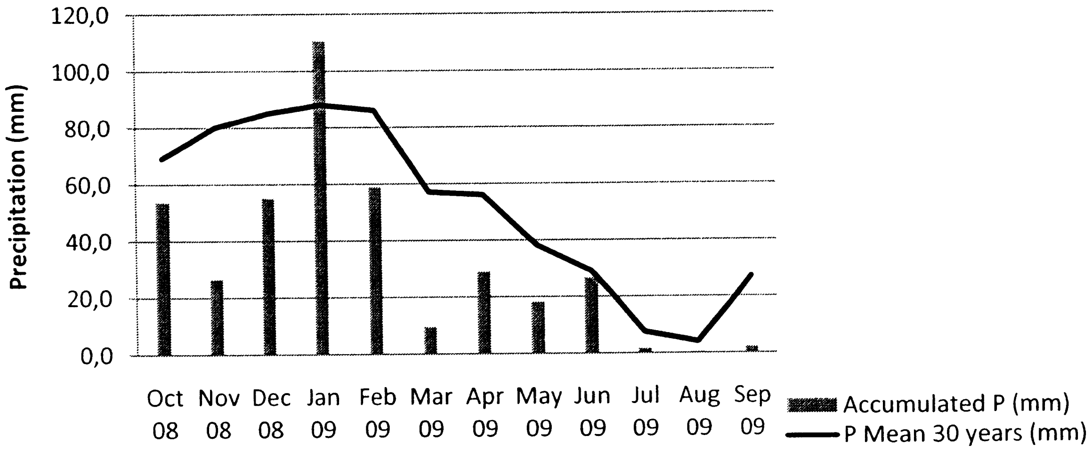

Figure 1 - Monthly precipitation observed (P (mm) Observed) for the hydrological year of 2008-2009 and mean monthly precipitation for last 30 years (P (mm) mean) recorded in the meteorological station of the "Herdade Experimental da Mitra" (from Centro Geofisica de Évora: http:www.cge.uevora.pt).

The stream section where monitoring took place was divided into seven reaches (Figure 2), each reach presented a certain homogeneity in the habitat patchiness, particularly in terms of depth, velocity of flow and substrate. Immediately upstream the reach 1, there is a dyke that acts as a natural barrier to the migration of fish in regular years from the hydrological point a view. The seven stream reaches presented a fairly uniform bank width, with approximately 9 m between margins. Most reaches, mainly the upstream ones, presented a relatively high number of riffles and patches of rocks and gravel, which are important sites for cyprinids' reproduction. The area further downstream (downstream S7, Figure 2) is already under the influence of Tourega reservoir, presenting a more lentic profile, with very flow velocity (0 to 0.1 m/s) and mean water depths around 1.5 m.. The reservoir presents an area of 639519 m^2, with low diversity of habitats. Water depth range from 2 to 3 m and substrate is dominated by mud. The water level is regulated by superficial discharge and there are no fish passages. Main use of this reservoir is for agricultural irrigation. The fish community in this watershed is dominated by cyprinids, in particular barbel (*Barbus bocagei*), carp (*Cyprinus carpio*) and the iberian nase (*Condrosthoma polylepis*), but non-native centrarchid species such as pumpkinseed (*Lepomis gibbosus*) and largemouth black bass (*Micropterus salmoides*) present also expressive abundance, particularly the former one.

Figure 2 – Location of study area, identifying the stream reaches of monitoring (reaches from upstream to downstream: 1 – S1, 2 – S2, 3 – S3, 4 – S4, 5 – S5, 6 – S6, 7 – S7).

Capture and marking

Fish capture began in November 2008, using an electric fishing gear transport back to battery 12 V, with a voltage suitable for water conductivity values. Fish collection took place in all the stream sampling units but only individuals measured longer than 25 cm of lenght were retained. Sampling procedure was carried out in order to cause as little disruption as possible, minimizing disturbance and avoid fish escape. Barbels to be monitored were captured between February 23th and March 23th. We opted for the surgical implantation of radio transmitters (TW4 single button cell tag, Biotrack Ltd.), with 3 g weight, not exceeded the 2% of body weight of individuals (Pinheiro *et al.*, 2004). The implants were performed in the field, trying to keep the procedure as simple as possible (Jepsen *et al.*, 2002).

We placed the fish in an anesthetic bath (with 0.4 ml of 2-phenoxy-ethanol per 1 liter of water) until opercular rate became slow and irregular, and subsequently transferred it to a table where the surgery was performed. The ventral incision, posterior to the pelvic girdle, allowed the insertion of the transmitter; its antenna was placed through a hole made in the lateral area of the abdomen with a blunt needle; finally, the cavity was closed with 2 or 3 stitches (depending on the size of the incision) with absorbable line (Vicryl). We passed liquid Betadine, with the aid of a gauze, over the sutures and on the spot where the antenna exits the animal's body, for better healing of interventioned areas. This procedure took between 8-10 minutes for each individual.

Release of the marked animals

After the surgery, barbels were placed inside a 60x45x30 cm hard plastic net boxes, kept on the stream in slow flow habitats, near capture sites for one day before release. Individuals who showed some signs of weakness were not released until it was possible to observe a recovery of swimming skills and a good response capacity to disturbance. The release of marked *B. bocagei* was made always near the site of capture, in locations that met the appropriate conditions for their upstream progress.

Telemetry

This technique is based on remote sensing of a signal, sent through transmitters placed in the animals to monitor (Sensu Kenward, 2001).

Barbels were radiotracked, following the "homing" technique (Mech, 1983), by foot from the stream banks, and by boat in the reservoir. We used a Lintec flexible 3-element Yagi coupled to a receiver Sika Radio Tracking Receiver (BioTrack Ltd).

Initially, from March 12th until March 30th, the fish were monitored daily; when found, recording their position. Between April and May were carried out 4 cycles of 24 hour of monitoring in the stream, covering the diel period; In July and August, 3 additional 24 hour cycles were performed in the Tourega Reservoir, with similar procedures. Diel cycles were then classified into 4 turns (6-10h, 10-18h, 18-22h e 22-6h), according to light intensity and temperature (CGE, unpublished data). In each turn, each barbel were followed for periods of 30 minutes, while recording their activity (rest, number of movements and type of movements – see field protocol in annex) and the characteristics of the habitat (mesohabitat type, water depth and refuge availability expressed in percentage of the used area) where they were found. These periods of 30 minutes were repeated throughout the turn at least 3 times.

Data Analysis

All coordinates of the locations (n = 1406) from the monitored barbels were projected onto Orthophotomaps (1:25000 - 2005) of the study area through ArcGIS 9.3.1 (ESRI ®). Study time was divided into six periods (P0 – Middle March (Acclimation), P1 – Late March-Early April, P2 – Middle April, P3 – Late April-Early May, P4 – Middle May and P5 – Late July-Early August). The period 0 integrate to the first three locations of individuals (within the first monitoring week), that correspond to the acclimation phase after the fish release. Before computing fish home ranges, we checked if barbels' locations were randomly distributed in the space or showed some pattern. For this we used the Rogers's (1998) approach described in Rogers & White (2007), using the software FishTel 1.4. Shortly, the software computes the variance in distances from random points to fish location and from random points to randomly generated pseudolocations, iterates them respectively 1000 and 10,000 times to generate the two distributions of the mean of variance estimates and test the null hypothesis of random distribution of the fish locations.

Total individual home-range was calculated as the distance between the locations further upstream and further downstream of that animal. Daily locations were used (fixes) untill May; then, when the cycles started, we randomly selected a location for each cycle and added into the fixes data set. We calculated the spring stream home-range (SS HR) and the summer reservoir home-range (SR HR). The SS HR was calculated only based on the locations within the stream, while the SR HR was calculated through the locations in the reservoir. The daily dispersal was calculated as the distance traveled by fish between locations in consecutive days. The overall distance travelled per day or fish daily mobility was calculated as the sum of all distance traveled along 24 hours and the daily home-ranges as the longitudinal distance between the most upstream and downstream location within a diel cycle. All the behavioral parameters were calculated with data from 24 hours cycle's locations. Finally, for each turn we estimated the frequency of movement and type of activity (Rest - R, Small Movement - SM $\leq$10 m, Medium Movement - 10 m<MM <30 m and Large Movement - LM$\geq$ 30 m).

To test differences between individuals and the dispersion and home-range by period, the daily distance and home-range and daily distance traveled in each turn, we used the nonparametric Kruskal-Wallis test. The same test was used to ascertain whether there were differences between individuals with regard to activity, type of activity and depth and refuge of selected areas by the barbs. For the same variables we also tested whether there were differences between periods, cycles and turns considering all individuals together. When the Kruskal-Wallis test revealed significant differences we resorted to the nonparametric Mann-Whitney test to identify individuals, periods, cycles or shifts differed. To test differences in type of movement exhibited by individuals and in turns we use the Friedman test. The daily dispersion and daily home range were correlated with environmental variables; climatic (daily precipitation, solar radiation and temperature) and habitat (water depth, current velocity and percentage of refuge from the areas used by the barbels) using the Spearman correlation. This test was also used to correlate the daily mobility with water depth and refuge of areas where the barbels were found in every diel turn. In all statistical tests was considered a significance level of 0.05. All tests were carried out using STATISTICA 7.0 (Stat Soft, Inc).

Results

During the study period a total of 1406 records were obtained from 9 tagged fish. Although a total of 13 fish were tagged with radio transmitters, four individuals (M34, M36, M37 and M38) were found only twice after their release in to the stream. Monitored barbels occupied home ranges from 535 to 3208 m long (Table 1). During the study period, all individuals, excepting one (F41), were located both the stream and reservoir. Individuals with higher home ranges were those followed during a longer period.

The mean variance statistic was 3179.2 m2. The spatial test statistic module of program FishTel based on 215 random pseudolocations showed that the probability of obtaining a mean variance value of 3179.2 m2 or larger by chance was remote ($p < 0.001$). The distribution of 215 barbels' observations was therefore nonrandom.

Table 1 – Total, spring stream and summer reservoir home-range and monitoring period of nine *B.bocagei* tracked in Valverde stream in 2009

Fish Code	TL (mm)	Sample size (n)	Monitoring Stream (spring)	Monitoring Reservoir (summer)	Track. Days	Total Home range (m)	Spring stream home range (m)	Summer reservoir home range (m)
M30	410	186	12/3 to 23/5	22/7 to 28/7	30	2370	935	118
F31	470	261	12/3 to 21/5	28/7 to 7/8	35	2748	709	170
F32	471	185	12/3 to 21/5	-	28	1511	974	-
F33	390	93	12/3 to 30/3	22/7 to 7/8	15	3208	362	670
M35	385	77	14/3 to 12/5	-	17	2445	1057	-
F39	390	232	22/3 to 23/5	22/7 to 7/8	30	2644	458	194
F40	380	101	22/3 to 15/5	-	16	811	351	-
F41	390	89	24/3 to 7/5	-	18	535	535	-
F42	535	182	28/3 to 13/5	22/7 to 6/8	26	2716	605	140

Home-range and dispersal along time

Between March and May fish were located extensively within the stream sector (aprox. 90% of records) while during July and August fish were found exclusively in the reservoir (Figure 3). During the spring, monitored fish visited the reservoir only once or twice, between middle March and early April, when they were mostly located in the upper part of the stream (reaches S1 to S5). Between March and April the stream conditions didn't show large variations in water depths (0.79 m and 0.74 m on average, respectively) and refuge (51.43%), but there was a considerable decrease in flow velocity (0.3 m/s to 0.1 m/s). In May the mean water depths and mean current velocity decreased to 0.55 m and 0.03 m/s, respectively, and the availability of refuge areas also decreased (42%).

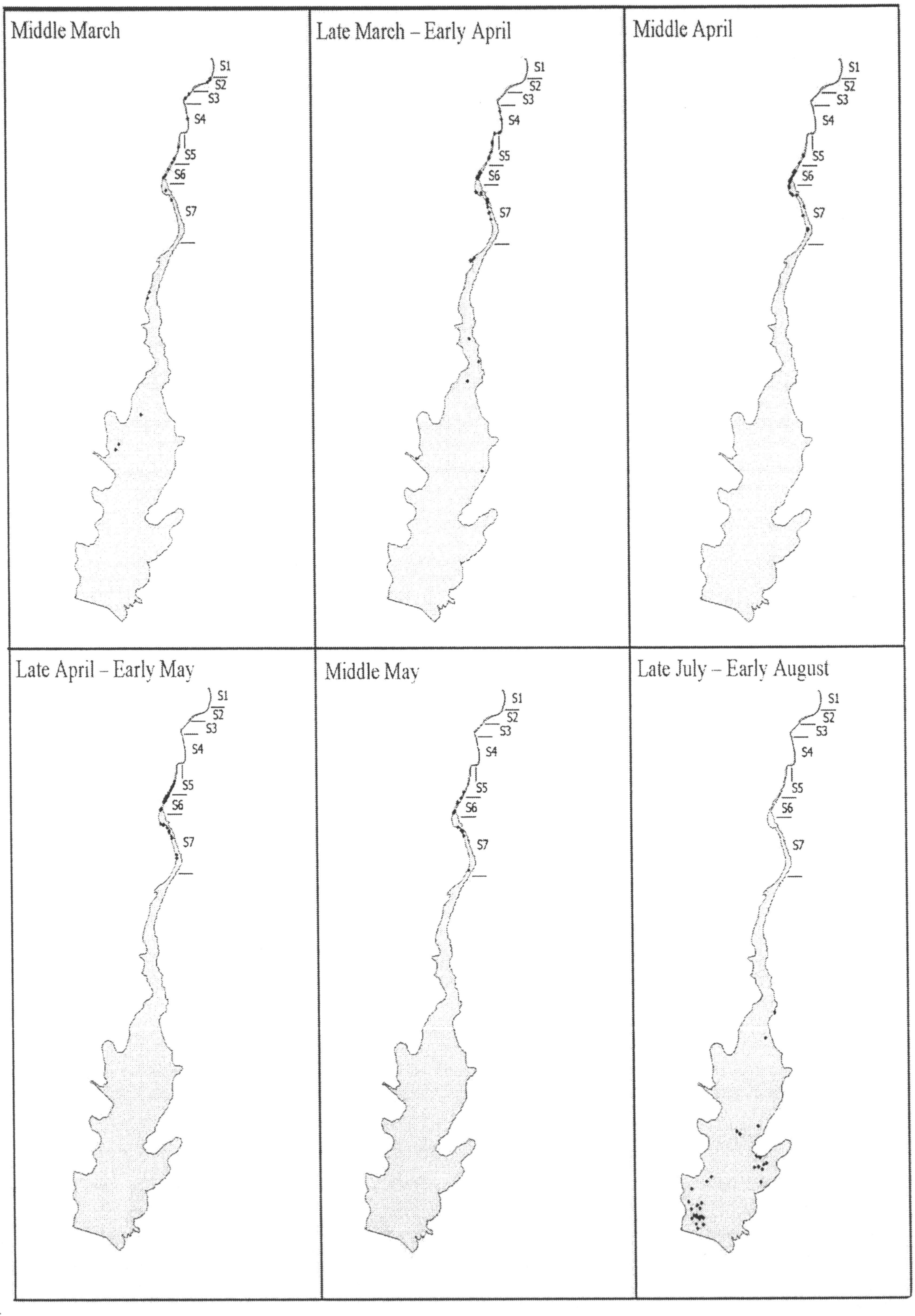

Figure 3 – Location of barbels monitored throughout the study periods (Middle March – acclimation Period).

On average, fish distance to the reservoir was higher during March and April, when the fish were found further upstream. From middle April on, barbels were never found in upstream reaches (above S4, Figure and 3). By the end of May fishes moved downstream toward to the area reservoir and in July all monitored fishes were already in the reservoir water body.

During the spring, fish distance to reservoir ranged between 1150 and 199 m. The distance of fish from the reservoir was negatively correlated with mean water depth (r = -0.6, p <0.001) and maximum water depth (r = -0.54, p <0.001), meaning that barbels moved downstream to deeper habitats along the study period (figure 4).

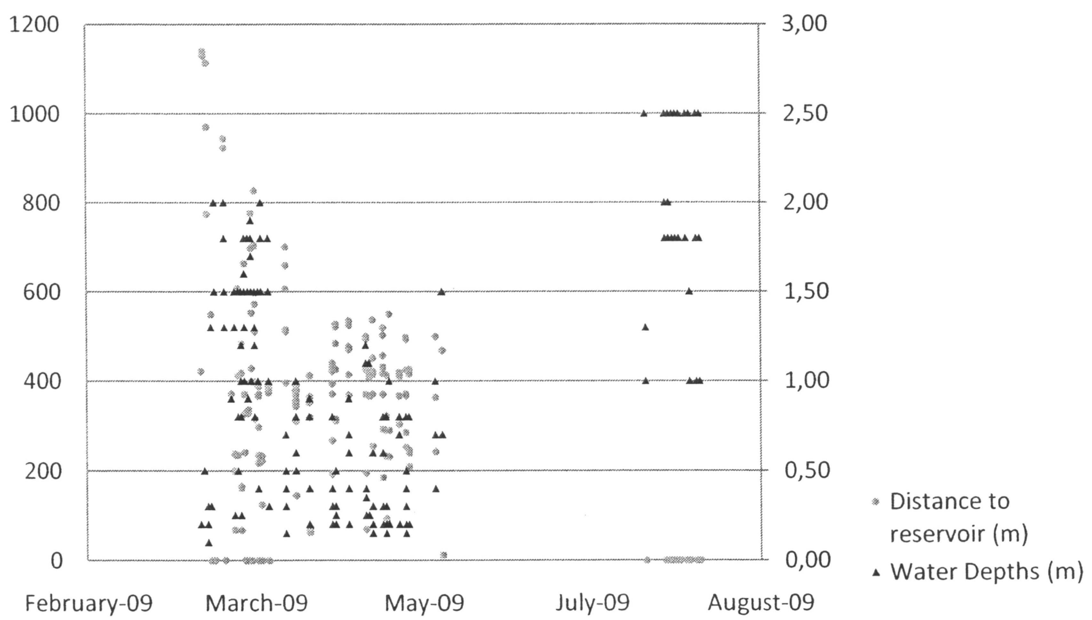

Figure 4 – Correlation between distance to reservoir (m) and water depths (m) throughout the study period.

The average fish home-range, per period, was also higher in the first two periods with 1049 and 989 m for Middle March and Late March-Early April, respectively. In the remaining periods, the home-range ranged between 159 and 233 m (Figure 5).

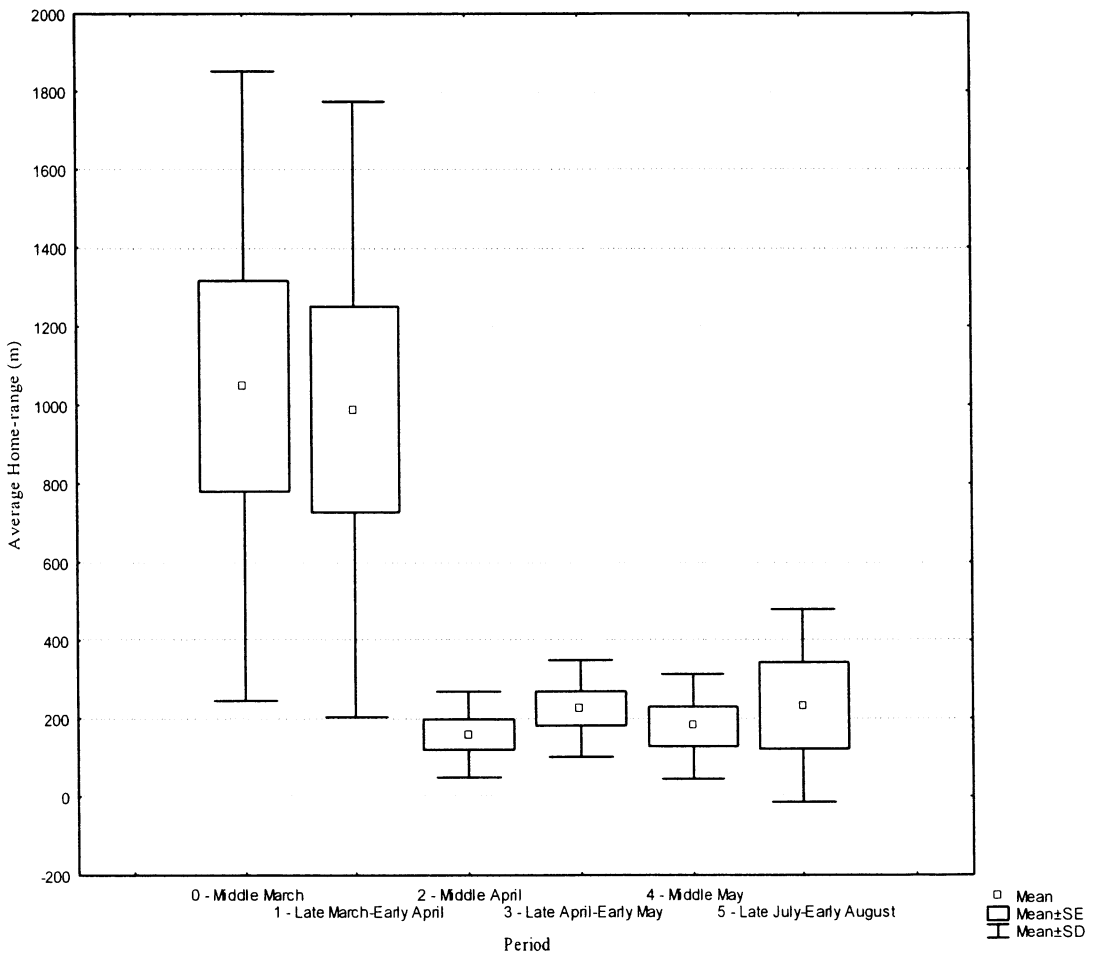

Figure 5 - Average home-range (between consecutive days) of fish along the monitoring periods.

Throughout all periods of monitoring, all individuals showed the same pattern of dispersal. The average dispersion of individuals was significantly higher in Middle March and Late March-Early April (373 and 271 m on average, respectively), contrary to what was observed at 2, 3, 4 and 5, when the animals presented significantly lower values ($p<0.001$) of dispersion, ranging between 46 and 67 m daily average (Figure 6). There was no correlation between daily dispersion of barbels and climate variables such as precipitation, temperature and radiation ($p> 0.05$).

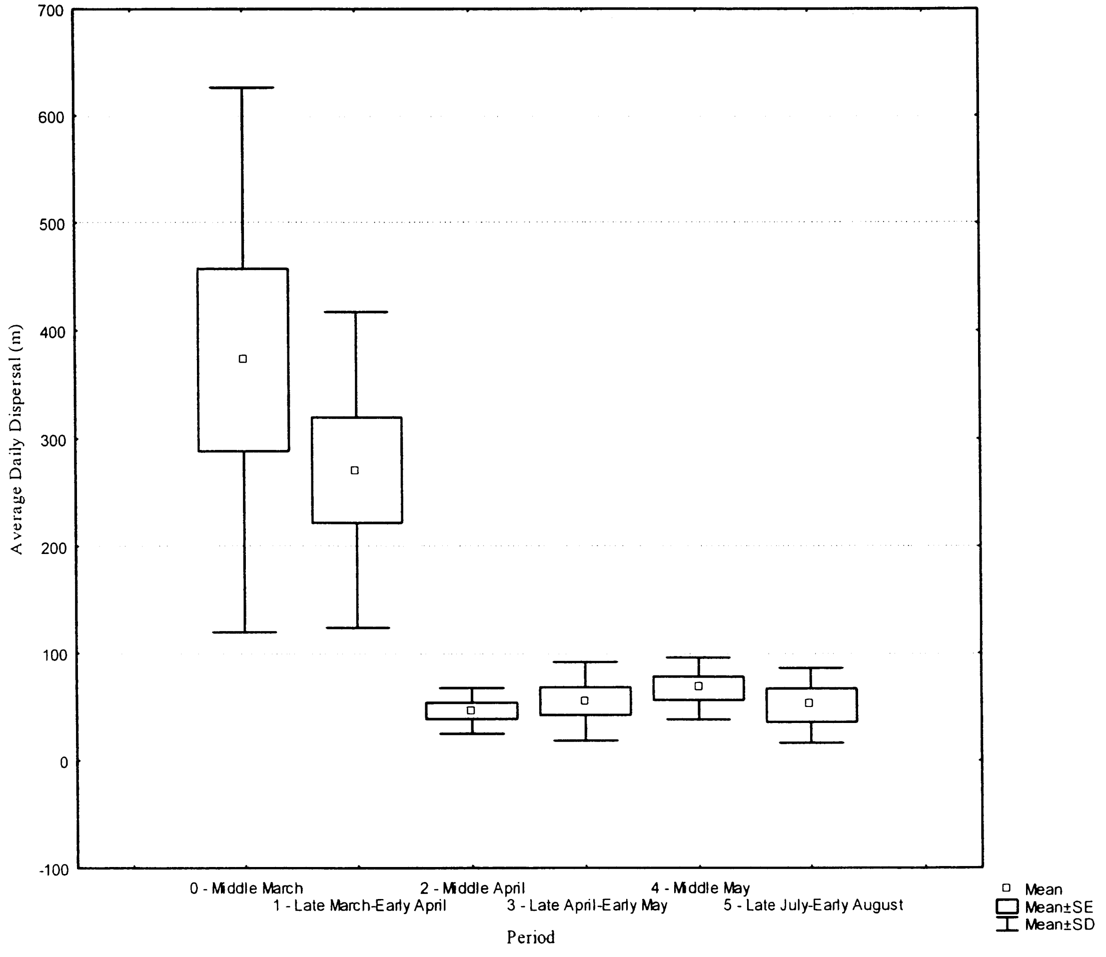

Figure 6 - Average daily dispersal (between consecutive days) of fish along the monitoring periods.

A relatively strong correlation between the current velocity and fish daily dispersion ($r = 0.77$, $p < 0.001$) and home-range ($r = 0.76$, $p < 0.001$) as observed. The percentage of refuge availability (substrate, roots and woody debris) was also significantly correlated with fish home-range ($r = 0.45$, $p < 0.05$) and daily dispersal ($r = 0.43$, $p < 0.05$), meaning that fish dispersion and daily home-range decreased with flow and refuge availability.

Diel mobility and activity

There were no statistically significant differences on the diel mobility and home-range, among individuals, both the stream and reservoir ($p > 0.05$). Diel mobility and daily home-range varied significantly along the study period ($p<0.05$). The highest diel mobility and home-range exhibited by barbels was observed among the first's cycles during the spring time, when fish used mostly the upstream (Table 2). Although diel mobility presented some variations along time, in a general way, after entering in the reservoir area, fish showed a lower significantly mobility and home-ranges ($p<0.05$). Was observed a small increase in average distance to reservoir from first to second cycle, being that, later, the distance was always decreasing, with the fish to occupy further downstream areas.

Table 2 – Diel mobility (sum of all distances within 24 hours cycle) and daily home-range exhibited in each 24 cycle (mean ± standard deviation)

24h Cycle	Diel mobility (m)	Daily Home-range (m)	Distance to Reservoir (m)
Stream			
10 April	624 ± 437	195 ± 104	349 ± 114
28 April	678 ± 358	183 ± 72	408 ± 100
10 May	948 ± 551	258 ± 142	357 ± 117
25 May	336 ± 100	185 ± 102	322 ± 146
Reservoir			
25 July	512 ± 396	146 ± 76	0 ± 0
1 August	325 ± 183	135 ± 44	0 ± 0
4 August	328 ± 43	140 ± 33	0 ± 0

We observed a negative correlation between water depth and daily distance traveled by fish ($r = -0.45$, $p < 0.05$), and home-range ($r = -0.41$, $p < 0.05$), in other words, in shallower areas fish showed higher mobility and larger home-range. Fish occurred in significantly lower ($p<0.001$) mean water depth in the stream habitats comparing to the reservoir habitats (Figure 7). Within the stream reaches, barbels occurred in habitats with 0.30 to 0.70 cm mean water depth while in the reservoir all fish were located in habitats deeper than 1.0 m (average around 2.0 m). The refuge availability and mean water depth were strongly correlated ($r = -0.73$, $p < 0.001$), meaning that barbels used either shallow habitats with high percentage of shelters and vice-versa.

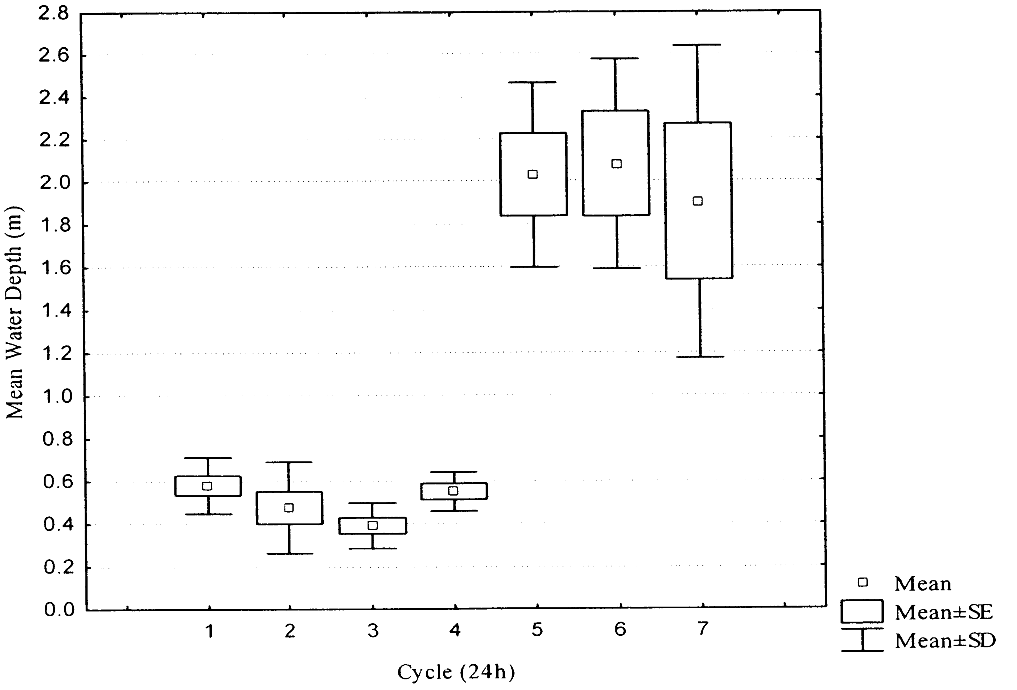

Figure 7 – Mean water depth (average values, standard deviation and standard error) from habitats used by *B. bocagei* in each of cycles of monitoring (1 – 10 April, 2 – 28 April, 3 – 10 May, 4 – 25 May, 5 – 25 July, 6 – 1 August and 7 – 4 August).

The highest percentage of refuges was recorded within the stream, in which fish used habitats with high shelter value (between 40 and 60 % on average) (Figure 8). In the reservoir, the, most fish locations presented low refuge availability, associated mainly with submerged vegetation or woody debris present in the margins.

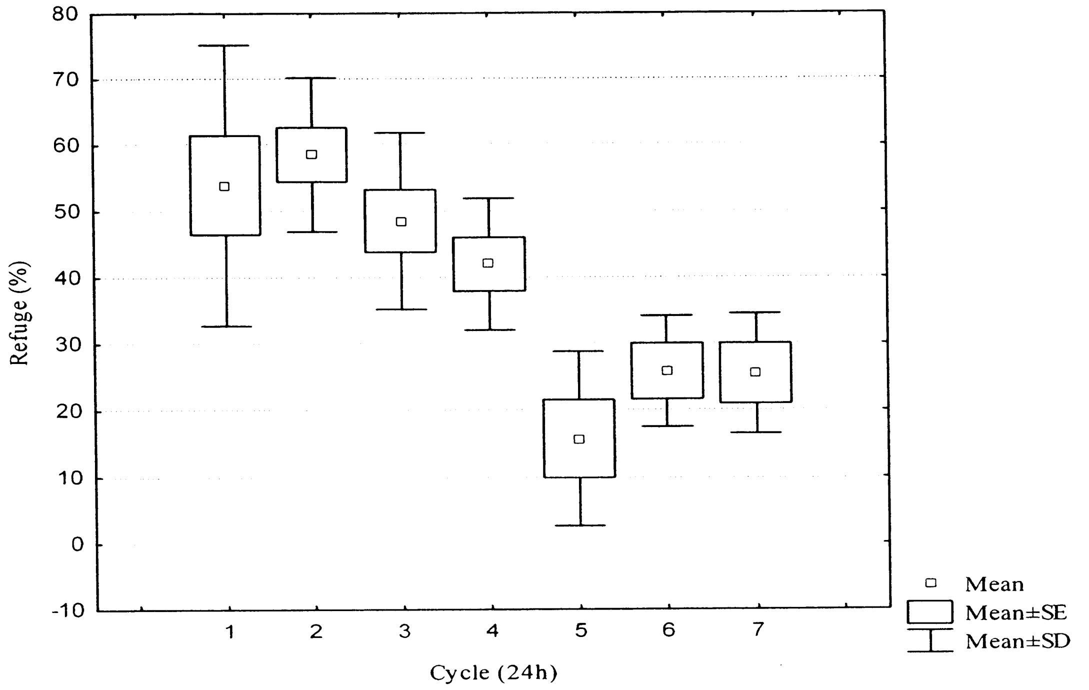

Figure 8 – Percentage of refuge (average values, standard deviation and standard error) by *B. bocagei* in each of the cycles of monitoring (1 – 10 April, 2 – 28 April, 3 – 10 May, 4 – 25 May, 5 – 25 July, 6 – 1 August and 7 – 4 August).

There were no statistically significant differences in the diel mobility behavior between individuals, over the rounds of monitoring, both in the stream and in the reservoir ($p > 0.05$). On average, barbels showed higher mobility in all turns in the reservoir but with no significant differences ($p > 0.05$). In the stream, fish present significantly higher mobility at dawn (6-10h) ($p < 0.001$) contrasting with the night turn (22-6h) in which the average distances traveled by individuals was very low. In the reservoir, barbels present significantly higher mobility at dawn and dusk ($p < 0.001$). At day and night turns, fish showed similar mobility ($p > 0.05$) with low distances (Figure 9).

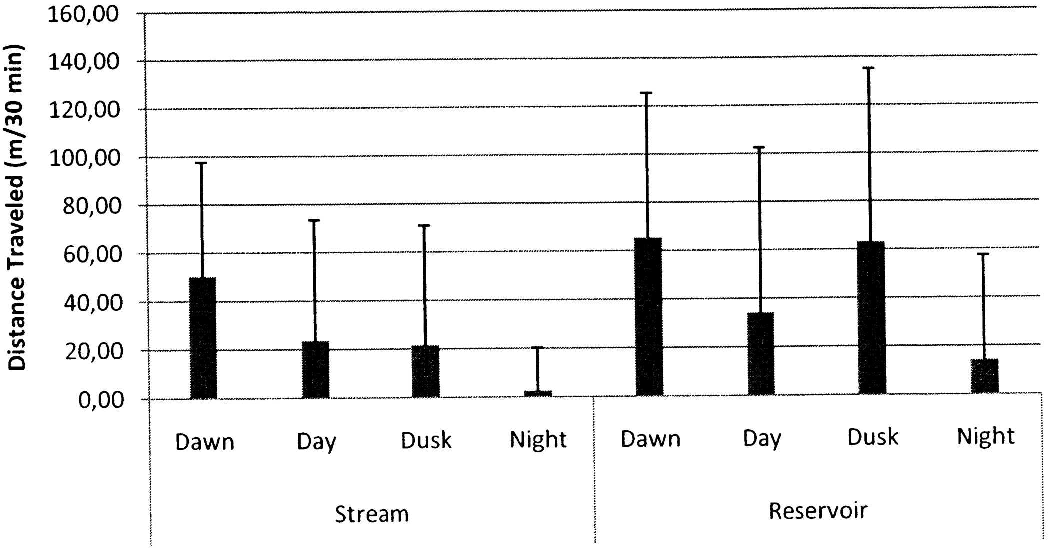

Figure 9 – Fish mobility (average values and standard deviation of distances (m/30 min)) scored by fish in each of monitoring turns.

The activity behavioral patterns between individuals showed no statistically significant differences ($p > 0.05$). In both systems, stream and reservoir, the rate of fish activity was significantly higher at dawn and at dusk ($p < 0.001$), although a relatively high frequency of movements were recorded during the day, particularly in the stream (Figure 10).

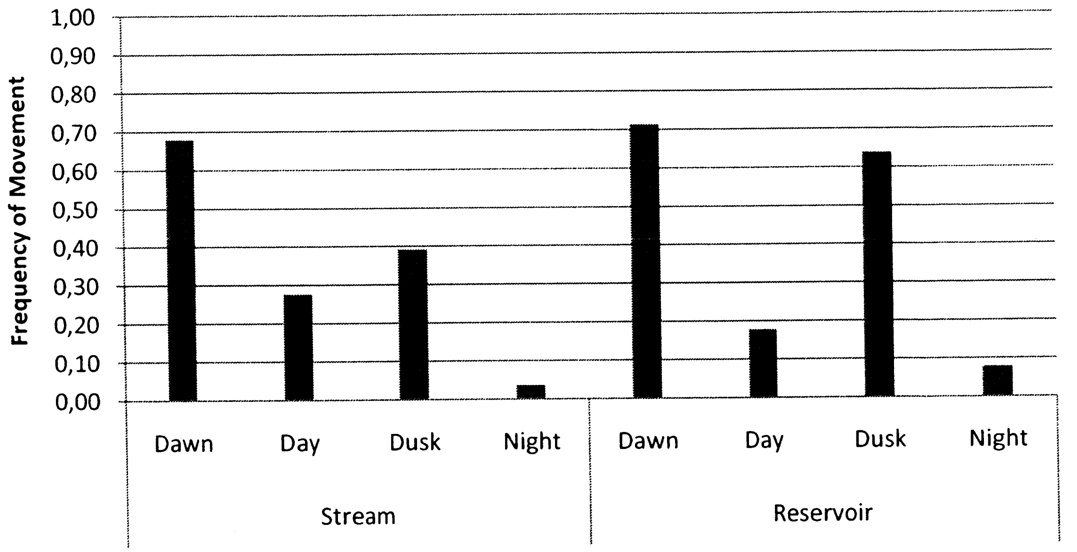

Figure 10 - Frequency of movements of marked animals in each monitoring turns.

Actually at night, fish were found in predominantly in rest conditions (with a frequency of occurrence above 95%). Again, larger and medium movements occurred mostly at dawn and at dusk (Figure 11). On average, barbels exhibited a high frequency of large movements (>30 m) mainly at dawn in the stream sector. On the opposite, the frequency of small movements was more representative in the reservoir, both at dawn and at dusk. There were no statistically significant differences in type of movement between individuals ($p > 0.05$).

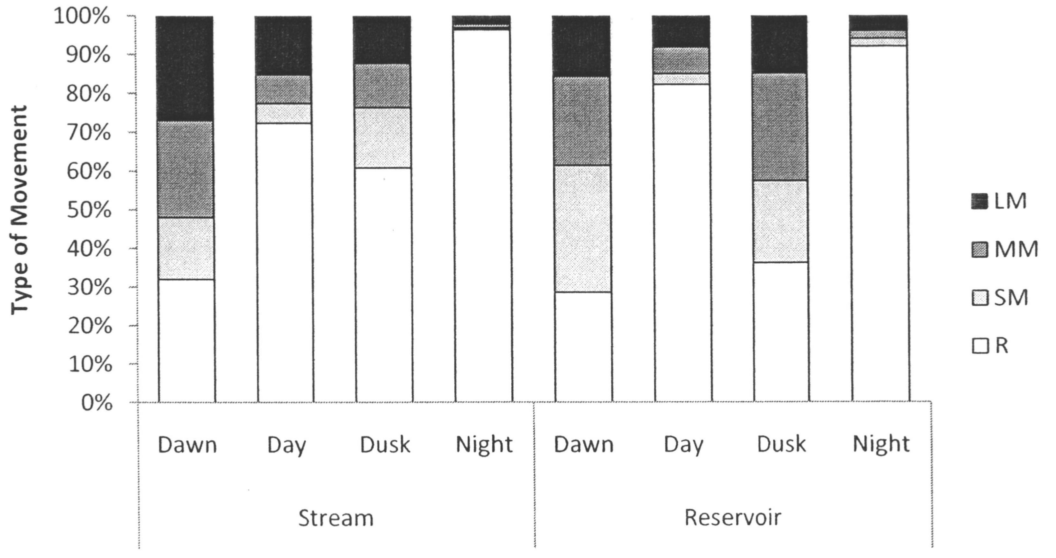

Figure 11 - Comparison of the percentages with which each activity contributes to the total activity in different turns (Rest - R, Small Movement - SM $\leq$10 m, Medium Movement - 10 m<MM <30 m and Large Movement - LM$\geq$ 30 m).

The mean water depths used by fish in all turns was significantly lower in the stream compared to the reservoir ($p<0.001$). Water depths showed a significantly differences between individuals in stream ($p<0.001$), being that in reservoir these differences were not observed ($p>0.05$). In the stream, fish showed significantly different use of water depth along the 24 hours; occurring in deeper habitats at dawn and shallow ones at night, with a decrease throughout the day (Figure 12). In the reservoir, there was no statistical difference on water depth use along the turns.

A positive correlation between the fish mobility in the turns and the mean water depth ($r = 0.24$, $p <0.05$) was observed, meaning that barbels used deeper habitats when they were more active, and tend to occur in shallower habitats during the rest periods.

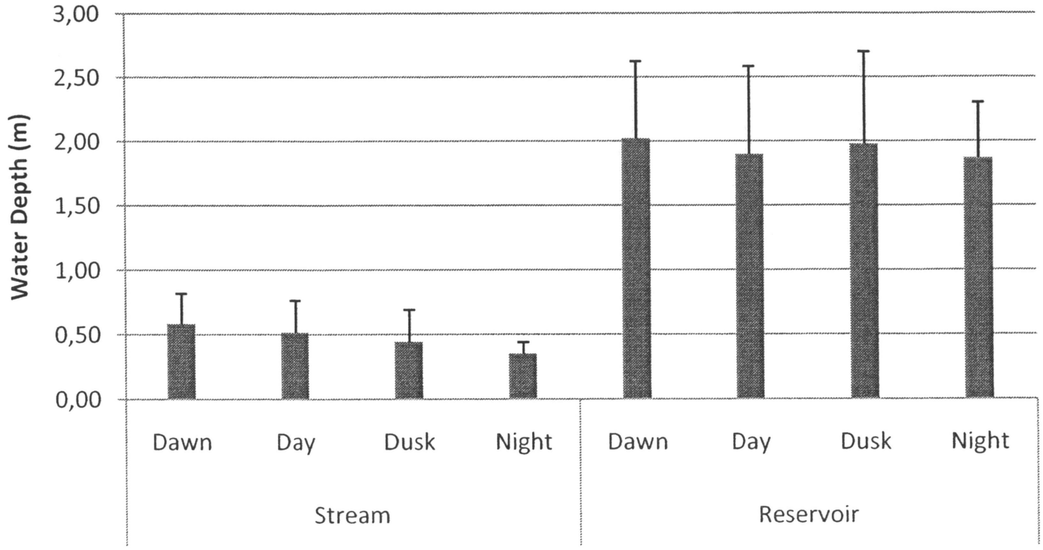

Figure 12 - Mean values of the water depth of the sites used by *B. bocagei* on each monitoring turns in the stream sector and in the reservoir.

At the diel base, water depth and refuge use was also negatively correlated ($r=-0.6$ $p<0.001$), meaning that when fish used shallower habitats, there was a increase in the use of shelter. In the stream, the use of habitats with high percentage of refuge increase throughout the day, being significantly lower at dawn (Figure 13), when fish are more active, showed a significantly differences between individuals ($p<0.001$). In the reservoir, similarly to the water depth use, there was no significantly difference on the diel use of refuges ($p>0.05$).

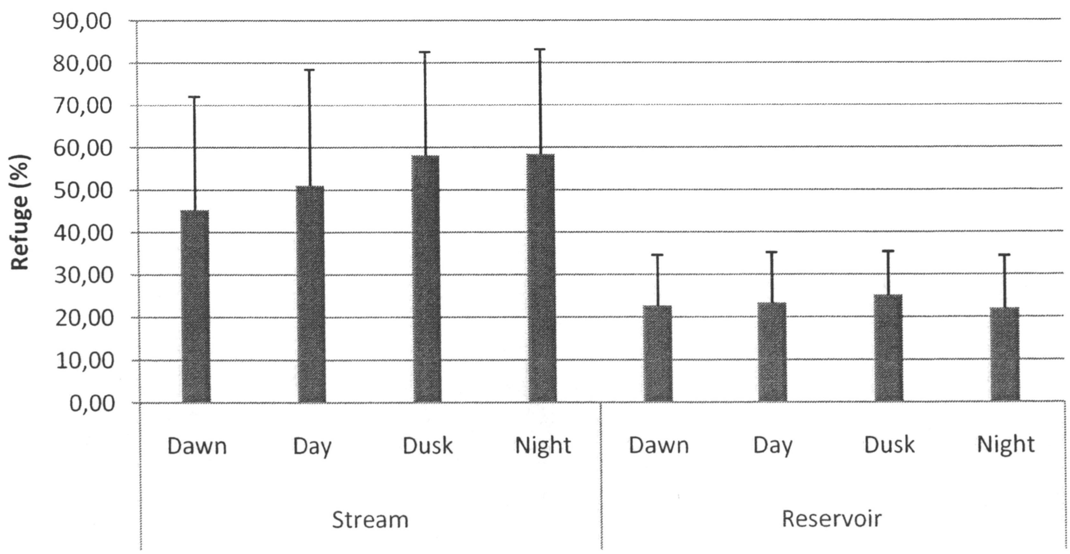

Figure 13 - Average percentage of refuge availability (large size substrate, aquatic vegetation and woody debris) in sites used by *B. bocagei* on each monitoring turns in the stream sector and in the reservoir.

Discussion

Over the past decades, there has been a growing interest in how the freshwater fish use and select their habitat, not only to assess their preferences and needs, but also the limits of tolerance of the species (Baras, 1997). Therefore, the increase in understanding of migrations, in recent years, has led to concerns over the possible impacts of connectivity loss on the distribution, population structures, spawning success and recruitment of many species (e.g. Ponton *et al.*, 2000; Quintella *et al.*, 2004; Almeida *et al.*, 2005; Nunn *et al.*, 2010). Indeed, migration constrains are now recognized as one of the threats of freshwater fishes, particularly for the recovery of impacted populations (Nunn *et al.*, 2010). A key factor in the natural functioning of river ecosystems is the hydrological connectivity between the rivers with their tributaries and flood plains (e.g. Copp, 1989; Lamouroax & Cattanéo, 2006). In rivers, limited access by fishes to key habitats may result from reducing of hydrological connectivity (Nunn *et al.*, 2010). The construction of dams and other water retention structures may impede freshwater fish movements (Peňáz *et al.*, 2002) and in small Mediterranean streams it is also important for fish to learn the stream sections that do not dry out during the summer drought (Aparicio & Sostoa, 1999). In the southern Iberian Peninsula, most river basins are fragmented by the present of dams; in these scenarios, reservoirs may present an important function on fish populations, as they may function as river backwaters. It has been demonstrated that fish community often presented migration between the river and backwaters (Schiemer & Waidbacher, 1992; Peňáz & Jurajda, 1993; Hohausová *et al.*, 2003; Hohausová & Jurajda, 2005). This interconnection was extremely important, in our study, because the reservoir played the role of summer refugia for monitored barbels. The broad pattern of barbel's movements in Valverde stream was similar to that of other barbell studies in temperate rivers (e.g. Baras & Cherry, 1990; Baras, 1992, 1993; Lucas & Batley, 1996) with a phase of upstream movements during the Spring followed by downstream migrations in early summer, specifically into the reservoir, in these case study.

Because of the migrations between the lotic (stream) and lentic (reservoir) system, the fish home-range along the study period was significantly higher in the individuals that occupied the two systems. The barbels defined a mean home-range extending of 2.01 km which was slightly higher than that observed in *Barbus barbus* in Meuse River (1.5 km) by De Vocht and Baras (2005). However, the summer home-range was much lower than that of the spring home-range, as it happened with Baras and Cherry (1990) in River Ourthe. Home-ranges are central to understanding habitat use, effects of fragmentation and develop conservation plans (Woolnough *et al.*, 2009). According to Gerking (1953), home range is understood as the area over which the fish normally travels, searching for the optimum element of habitat (patch, microhabitat) required at given time and phase of its life cycle. In barbels home-range selection and use is conditioned not only by the availability of suitable physical habitat, mainly feeding areas, but also by the actual status and abundance of the population (Baras, 1997; Peňáz *et al.*, 2002). This was corroborated in our study, in which the pattern of fish home-range was highly influenced by environmental conditions of the study year. The upstream migration, both the timing and the traveled distance, was conditioned by the reduced precipitation and flow observed in the year of 2009, which was particularly dry (Figure 1). The upstream migration by fish to attempt the spawning habitats was considerable limited due the lack suitable stream flow until March, therefore barbels did not reached the upstream above the study area, where they were observed in previous years (Ilhéu, unpublished data). Moreover, along the study period, fish movements were conditioned by the availability of water within the stream, and the perception of it by fish. Long movements within the river network (aprox. 2 Km in one day) were exhibited by several fishes, especially during March and April, which can be interpreted as exploratory behavior of fish to assess the stream habitat conditions and their suitability for barbel's maintenance in the sector. In temporary streams, the perception of the risk conditions by fish is extremely important in order to avoid the confinement in isolated pools that present low probability of persistence along the summer (Ilhéu, 2004).

Through the analysis of all the daily locations, barbels exhibited large dispersal behavior until middle April, when they used mostly the upstream sector, probably searching for reproductive habitats. In the first monitoring days (acclimation period), a high dispersal rate of fish occurred as expected, due to the induced stress caused by the catch and surgical tags implantation, but this behavior seems to be restricted to the first week. From late April on, the stream presented low mean water depth (aprox. 0.5 m) and reduced flow (<0.1 L/s), and fish moved downstream to a relatively restricted area where they presented lower dispersal and lower daily home-ranges. The maintenance of barbels in this stream reaches may be related to habitat features, in terms of shelter good conditions (water depth > 0.8 m, and high availability of refuge; tree roots, macrophyte vegetation, rocks). A similar behavior was observed in Alva River by Pinheiro *et al.* (2004) and Peňáz *et al.* (2002) in Jihlava River.

Results from this study show a strong relation between water depth and the daily mobility of fish. In shallower areas (lotic system) the distances traveled by barbels were superior compared to the deeper ones (lentic system). Although this pattern may be associated with barbel's reproduction, it also can result from the high rate of individual's movements between shelters in low water depth conditions in order to reduce predation risks. Similar results were obtained in Llobregat River with *Barbus haasi* (Aparicio & Sostoa, 1999).

We observed two distinct patterns of diel activity of barbels, in terms of mobility (distance per time) and frequency of movements. In the reservoir fish were particularly active based on traveled distance per hour at dawn and dusk when significantly larger displacement and higher number of movement's ocurred. On the stream, fish were particularly active at dawn, when large movements took place. Regarding the type of movement, the pattern exhibited by fish was similar in both systems, with the peak activity at dawn and dusk, although, in the reservoir, fish tend to perform mainly small movements in contrast to stream, where large movements were dominant. This result is consistent with prior studies on the rhythms of activity of fish (Baras & Cherry, 1990; Baras, 1995). As other barbel's species (e.g. *Barbus barbus,* Baras & Cherry, 1990), *B. bocagei* may be classified as a crepuscular specie, according the Helfman's classification (1986); individuals are particularly active during periods of rapidly changing intensities of light throughout the study period. There are two hypotheses that can sustain the observed behavior. Firstly, the risk of predation can influence the activity of fish (Nunn *et al.*, 2010). Preys are able to assess predation risk and adjust their habitat use accordingly. It is likely that the ability to respond to the risk of predation not only affects the distribution and growth of the prey, but also reproduction and survival (Bryan *et al.*, 2002), thus regulating the rhythms of activity of prey. Otters (*Lutra lutra*; Linnaeus, 1758) are common top predators in Mediterranean freshwater ecosystems (Ruiz-Olmo *et al.*, 2002; Clavero *et al.*, 2003). In the study area it is known that otters feed mainly fish and crayfish and that Valverde stream basin is included on the territorry of one otter family (one adult female and two young males) (Quaglietta, PhD thesis, in prep.). Otters tracked in this area demonstrate that individuals usually start their activity from dusk on, throughout the night (Quaglietta, PhD thesis, in prep.). Thus the observed low activity of the barbels during these periods seems to be a strategy of minimizing predation risk. Mean water depth in the stream varied from 0.8 to 0.5 m along the Spring. Under these conditions fish might easily be susceptible to otter predation. On the reservoir, water depth offer high cover value to fish and more effective escape opportunities from predators, thus explaining partially the increase of dusk activity in this system. Secondly, the light intensity has been raised as a hypothesis to play an important role in fish activity. It's known that diel fish activity is influenced by light intensity, not only because of the predator prey interactions but also due to its effects on fish metabolism (e.g. Spencer, 1939; Cerri, 1993; Valdimarsson *et al.*, 1997; Didrikas & Hansson, 2009). In the present study the diel pattern of ligh and temperature varied considerable along the time. During spring, temperature were considerable low and sunset was quite short (CGE, unpublished data), comparing to the summer, when barbels occurred in the reservoir, thus explaining the higher mobility of fish in this period, both at dawn and dusk.

In the resting periods, fish tend to use lower depths habitats with and high percentage of refuges, contrary to what happens when they are more active. This pattern indicates that at night barbels at are more likely to select areas that offer them good shelters for protection, while in the periods of higher activity, individuals tend to use water depth as cover instead of fixed shelters, allowing them to perform their feeding and reproductive needs. The use of deeper habitats during the light period, suggest there is an actual risk of being predated by terrestrial species which rely on visual detection. This result emphasizes that barbel's behavior in Valverde stream, are influenced by predation pressure, and strongly related with the presence of the otter. In this context barbels behavior, exhibited a compromise between habitat needs for foraging and breeding, predation pressure and environmental constraints imposed by the dynamics of stream flow seasonality.

Conclusion

The stream where this study took place present a low drainage area and small dimension compared to other rivers where similar studies undertaken (e.g. Pinheiro *et al.*, 2004). This factor, coupled with the fact that the Valverde stream is temporary, makes the trophic relationships among organisms very close, because the probability of an encounter between a predator and prey (e.g.) is much higher, due to reduced dimension of habitats. Thus maintain habitat complexity and the connectivity between of these temporary streams and adjacent reservoirs it is extremely important for the functioning of riverine ecosystems and fish populations' health. The longitudinal connectivity is also essential for barbels access their reproductive habitats and maintain sustainable populations. The flow assumes a vital role in the maintenance of longitudinal connectivity and mosaic of habitat, because without a minimum flow the upward migrations and recolonization can be compromised, as happens in particularly dry years and/or highly fragmented habitats. Within the stream sector, it is also important to prevent habitat degradation or promote rehabilitation of freshwater habitats to ensure the reproductive success of the species. For this, not only is extremely vital identify reproductive habitats for this species, but also recognizing the special needs in the mosaic of habitat. It is, therefore, important to promote the complexity of lentic system and improve water quality of this important summer refuge for fish.

It would be interesting to conduct further studies in other temporary streams, in order to understand how far one can generalize the predator-prey relationship as influential activity in this context and evaluate the role of other Iberian reservoir as summer refuge for potamodromous species and their constrains for fish populations. It is also important to monitor ascending migrations in order to identify environmental factors that determine the success of recolonization and the maintenance of populations. Thus, improved methods for assessment of fish movement behavior and activity are needed to provide more precise information about the freshwater fish ecology in constrain scenarios for fish populations, as the ones that are nowadays present in most Southern Mediterranean River Basins. Barbels present large home-ranges and high dispersal movements along the river network which emphasize the requirement of a Fish Conservation strategy at the river basin scale.

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6. Considerações finais

Com este trabalho pretendeu-se evidenciar alguns dos principais padrões comportamentais do barbo-comum ao nível do movimento e actividade. A generalidade dos resultados apresentados está de acordo com estudos realizados com outras espécies de barbos em rios temperados.

Entre os principais resultados obtidos sobressaem as questões relacionadas com o home-range na ribeira e albufeira, a dispersão nos diferentes períodos de estudo, a distância em relação à albufeira, as fases do dia com maior actividade e ainda a relação predador-presa.

Relativamente ao home-range, verificou-se que os barbos apresentaram maiores áreas vitais na ribeira, relativamente à albufeira, provavelmente devido à sua procura de melhores condições de habitat para a respectiva reprodução. A dispersão dos animais monitorizados foi superior nos 2 primeiros períodos de estudo, que abrangeram o mês de Março e inicio de Abril. Nesta altura a ribeira de Valverde ainda apresentava um volume de água considerável, tendo ocorrido ao longo de Abril e Maio um progressivo decréscimo na profundidade da água e da velocidade da corrente. Consequentemente a distância média das zonas utilizadas pelos indivíduos em relação à albufeira foi diminuindo a partir desse período.

As fases do dia em que foi registada maior actividade por parte dos indivíduos ocorreram nos crepúsculos (matutino – 6-10h; vespertino – 18-22h). Este padrão foi observado tanto na ribeira como na albufeira, com os picos de actividade ao amanhecer e anoitecer, colocando-se a hipótese da actividade da Lontra (*Lutra lutra*) presente na área poder influenciar o comportamento dos barbos. O início do período de actividade da lontra coincide com a diminuição acentuada da actividade dos barbos, particularmente na ribeira. O padrão de comportamento de *B. Bocagei* parece resultar de uma estratégia de compromisso entre a necessidade de habitats reofilos, essenciais para a reprodução, a protecção contra predadores e o evitamento dos constrangimentos ambientais impostos pela sazonalidade do regime de escoamento típico dos cursos Mediterrânicos.

Apesar dos resultados obtidos se terem revelado bastantes interessantes, estudos mais aprofundados são necessários com o fim de compreender melhor as estratégias ecológicas de *B. bocagei* em diferentes contextos ambientais. É extremamente importante manter a complexidade do habitat e a conectividade entre os cursos de água temporários e os cursos principais ou albufeiras que fragmentam a rede hídrica, para assegurar o sucesso das migrações reprodutivas e o recrutamento das populações. Para isso, não só é vital identificar os habitats de reprodução para a espécie, mas também reconhecer as necessidades especiais ao nível do mosaico de habitat. É, portanto, importante promover a complexidade do sistema lêntico e melhorar a qualidade da água deste importante refúgio de verão para a ictiofauna do sul da Península Ibérica. Seria interessante a realização de estudos em outras ribeiras com estas características, a fim de compreender o quanto se pode generalizar a relação predador-presa como factor determinante na actividade dos peixes e avaliar o potencial de outras albufeiras como refúgio de estival para as espécies potamodromas.

Assim, é imperativo promover estudos de larga escala temporal e espacial a fim de compreender o comportamento destas espécies. Em cenários de elevado constrangimento para as populações piscícolas como os que estão hoje presentes na maioria das Bacias Hidrográficas do Sul de Portugal assim como de outros países Mediterrânicos.

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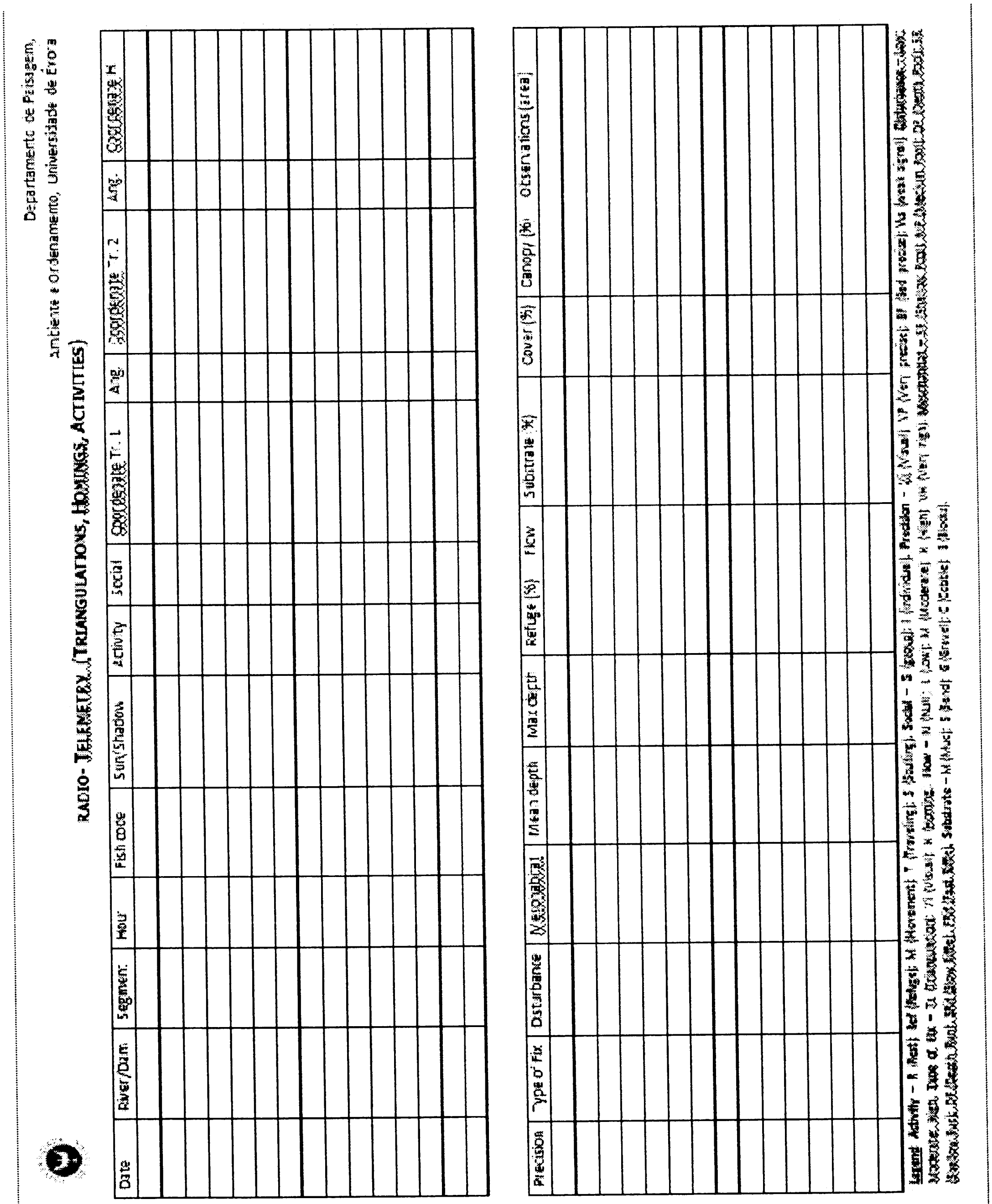
8. Anexos

Anexo 1 – Ficha de campo.



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RADIO-TELEMETRY (TRIANGULATIONS, HOMINGS, ACTIVITIES)

Date	River/Dam	Segment	Hour	Fish code	Sun/Shadow	Activity	Social	Coordenate Tr. 1	Ang.	Coordenate Tr. 2	Ang.	Coordenate H

Precision	Type of Fix	Disturbance	Mesohabitat	Mean depth	Max depth	Refuge (%)	Flow	Substrate (%)	Cover (%)	Canopy (%)	Observations (area)

Legend: Activity – R (Rest); Ref (Refuge); M (Movement); T (Traveling); S (Scuffing). Social – S (group); I (individual). Precision – V (Visual); VP (Very precise); BP (Bad precise); Ws (weak signal). Disturbance – Low; Moderate; High. Type of Fix – Tr (Triangulation); Vi (Visual); H (homing). Flow – N (Null); L (Low); M (Moderate); H (High); VH (Very high). Mesohabitat – SP (Shallow Pool); MP (Medium Pool); DP (Depth Pool); SR (Shallow Run); DR (Depth Run); SRi (Slow Riffle); FRi (Fast Riffle). Substrate – M (Mud); S (Sand); G (Gravel); C (Cobble); B (Blocks).