# ARRIVAL OF EUROPEAN EEL IN BELGIAN PART OF THE MEUSE: WHO AND HOW ARE THEY?

BILLY NZAU MATONDO, JEAN-PHILIPPE BENITEZ, ARNAUD DIERCKX, JEAN-CLAUDE PHILIPPART & MICHAEL OVIDIO

*University of Liège, Applied and Fundamental Fish Research Center (AAFISH-RC), Biology of Behaviour Unit, Laboratory of Fish Demography and Hydroecology, Quai van Beneden 22, 4020 Liège, Belgium*

## Introduction

When entering rivers, European eels *Anguilla anguilla* from sea colonize rapidly upstream, driven by density at the point source and, dispersion becomes after this initial phase, much low equivalent to random diffusion of particles in yellow eels (Ibbotson *et al.*, 2002). Frequently, eel colonization is disturbed by inland water barriers that reduce watershed connectivity and impede the final stage of the colonization process (Lucas and Baras, 2001; Ordeix *et al.*, 2011), but effective fish-passes may allow yellow eels to continue upstream migration to wider parts of river basins (Knights and White, 1998).

In the Meuse River, at Lixhe in Belgium near the border with the Netherlands, more than 300 km from the estuary, a dam for hydroelectric production is equipped with two multispecies fish-passes: – the old pool and weir configuration (OFP) built in 1980, is located between the hydroelectric plant and the spillway and equipped with a nonselective cone-trap pool and – the new vertical slot configuration (NFP) built in 1999, is located on the right bank and equipped with a cage-trap selective toward large fish and presents higher discharge and attractive flow, larger pools and deeper slots than the OFP. However, the precise entering stock of upstream migrant eels useful to predict potential escapement of silver eels according to the Eel Recovery Plan and the migration dynamics of these migrant populations are still unknown, partly because the trap of the new vertical slot configuration fish-pass does not retain eels.

Using adequate trapping in fish-passes, mark-recapture and automatic transponder detection, this study aims to further investigate eel migration dynamics, utilization and fidelity

rates to two different types of fish-pass, the stock of incoming eels in Belgium and the life stage of migrant eels.

**Material and methods**

From April to September 2013, captures of upstream migrant eels were made twice a week in the nonselective cone-trap pool for the OFP and net traps installed in the three resting pools and the upstream canal of the NFP. Eels caught were anesthetized with 2-phenoxy ethanol (0.5 mL/L), counted and measured. To assess recapture and detection, eels longer than 285 mm and weighing more than 24 g were individually identified using radiofrequency identification (RFID) tags, while smaller eels were released 0.3 km upstream of the Lixhe dam. Each capture was followed by the tagging and release of eels from the right bank 0.3 km downstream of the Lixhe dam. This unique release site allows random dispersal of tagged eels throughout the untagged eel population and prevents favoring OFP or NFP during their second passage when they were recaptured or detected through the RFID-detector. At each capture, recapture and detection, temperature, flow and moon phase were also recorded. Observations were made in variations of catch per unit effort (CPUE, total number of eels caught daily) according to temperature, flow and lunar cycle; the relationship between the length and weight of the eels caught; daily variation in mean length during the catch season; recapture rate; detection rate; fidelity rate towards a specific fish-pass; diel activity rhythm of passage; fish-pass utilization rate; eel stock assessment using the modified formula of the Schnabel estimate and life stage of migrant eels.

**Result and discussion**

From April to September 2013, 435 eels (median, 403 mm; range, 196–836 mm) were caught (daily maxima catch, 90 eels per day) in two fish-passes at Lixhe, 90% between 13 June and 1 August (50 days) and *P*50 on 19 July. Eels migrated mostly at 19–26°C (*P*50, 24.4°C), river discharge 65–314 $m^3$/s (*P*50, 84 $m^3$/s), during the dark at 00:00–05:00 and

during both waxing and waning phases of moonlight. During the migration season, the mean length of eels caught decreased. Recapture (6.8%) and detection (37.4%) were observed from 396 tagged eels released 0.3 km downstream of the Lixhe dam, showing median annual migration rates of 1.3–2.2 km per year (fastest: 14–43 km per year) and migration flux of 1156–7184 eels (0.139–0.863 t), with most eels probably migrating through a sluice downstream of Lixhe to reach the upper Meuse via the Albert canal. Eels moved almost independently of the configuration and location of fish-passes, but most eels displayed fidelity to the capture fish-pass. A representative sample of 50 eels showed migrant eels within a wide range of size and life stages, with 80% belonging to the yellow eel stage and 6% having a larger size and advanced continental silvering process corresponding to the migrating stage before transatlantic migration.

This study has clarified key aspects on the ecological and demographic parameters of eels entering Belgium through fish-passes at Lixhe on the Meuse River. Although the RFID-detection approach requires further development on stock assessment, results here illustrate its potential application to inform various aspects of migration dynamics of eels in large rivers. Its good performance revealed by an overall 37.4% detection rate of eels and accuracy of detection time combined with a 6.8% recapture rate, allowed us to collect further data on environmental migration conditions, the utilization rate of fish-passes and estimation of stock, including annual growth. Our results at a site a long distance from the tidal limit showed ecological conditions of migration in the norm of yellow eels but migration period appears very late and migration flux and rates much low compared to those observed farther upstream on the Meuse and a wide range of size and life stages in migrant eels (Baras *et al.*, 1996; Tesch, 2003; Durif *et al.*, 2005; Ovidio *et al.*, 2013). These ones raise relevant questions on the exact status of these eels at Lixhe (are they nomadic eels coming from the sea or resident eels of the Meuse?), their age (how many continental summers have they lived?) and their sex

(are they females or males?), as well as on the utilization of fish-passes (does the configuration of fish-passes meet the needs of eels according to their morphology and swimming capacity?). From implications for eel managements, this study demonstrated that modern fish-passes are not preferentially used by eels in upstream migration showing the need to think before removing the old configuration fish-passes (low flow) in rivers where eels are an important issue; eels migrate at specific time at seasonal and nycthemeral levels helping to promote more intelligent management plans of hydropower plants when eels are colonizing; and current knowledge of the stock and developmental stage of incoming eels in the country will ultimately enable better predict the rate of silver eel outputs, even if for the moment, the knowledge is not yet sufficient. Further investigations in the future over several years and the whole Meuse basin using a combination of methods including capture, recapture and RFID-detection through fish-passes will help better understand migration dynamics and demographic evolution of incoming eel stocks in Belgium.

## References


Baras E, Philippart JC, Salmon B. 1996. Estimation of migrant yellow eels stock in large rivers through the survey of fish passes: a preliminary in the River Meuse (Belgium). In Cowx I. G. (ed.): *Stock assessment in inland fisheries*. Oxford Fishing news books (Blackweel), London, U. K., pp 314–325.

Durif C, Dufour S, Elie P. 2005. The silvering process of *Anguilla Anguilla*: a new classification from the yellow resident to the silver migrating stage. Journal of Fish Biology 66: 1025–1043.

Knights B, White EM. 1998. Enhancing immigration and recruitment of eels: the use of passes and associated trapping systems. Fisheries Management and Ecology 5: 459–471.

Lucas MC, Baras E. 2001. Migration of Freshwater Fishes. Blackwell Science: Oxford.

Ibbotson A, Smith J, Scarlett P, Aprahamian MW. 2002. Colonisation of freshwater habitats by the European eel *Anguilla anguilla*. Freshwater Biology 47:1696–1706.

Ordeix M, Pou-Rovira Q, Sellarès N, Bardina M, Casamitjana A, Salà C, Munné A. 2011. Fish pass assessment in the rivers of Catalonia (NE Iberian Peninsula). A case study of weirs associated with hydropower plants and gauging stations. Limnetica 30: 405 – 426.

Ovidio M, Seredynski A, Philippart JC, Nzau Matondo B. 2013. A bit of quiet between the migrations: the resting life of the European eel during their freshwater growth phase in a small stream. Aquatic Ecology 47:291–301.

Tesch FW. 2003. The eel, Thorpe J.E. (ed.), Blackwell Science, Oxford (UK), 416 p.