Migration of the Plaice Eye *Grenham Ireland*

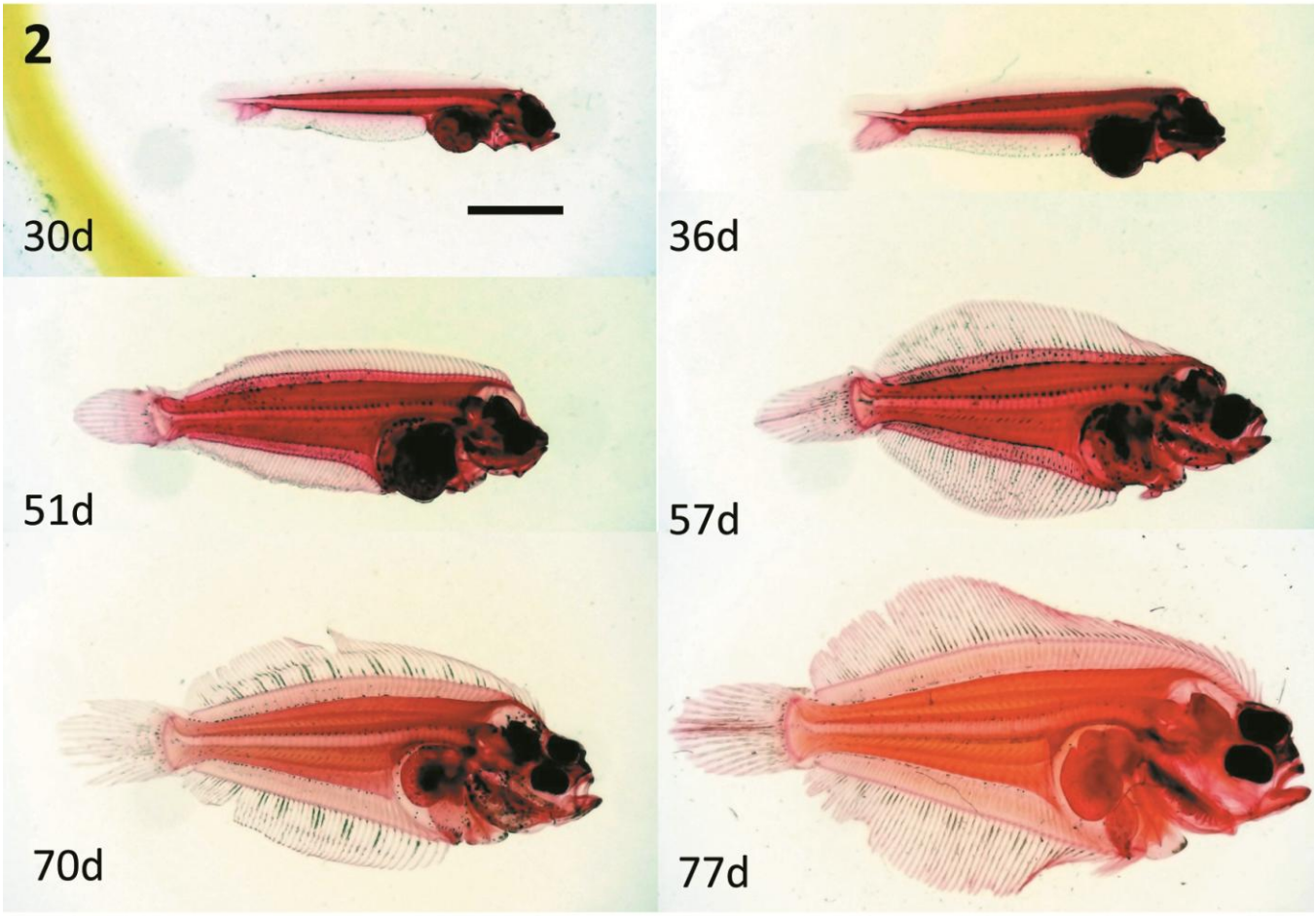
Introduction

Adult plaice (*Pleuronectes platessa*) are a benthic (bottom-living) species flattened laterally and effectively lying on their left hand side with both eyes on the upper (right) side (Fig. 1). However young plaice start bilaterally symmetrical with an eye on each side of the head. During development, there is a 'migration of the eye' to the opposite side and the fish become twisted looking. This is characteristic of a number of benthic 'flatfish' but the mechanism underlying this morphological change has not been understood.

Fig. 1. Adult plaice showing both eyes on the right hand (upper side) (Attribution: © Hans Hillewaert, https://commons.wikimedia.org/wiki/File:Pleuronectes_platessa.jpg)

Slide set and what is shows

A few years ago, I purchased a series of six slides made by Flatters and Garnet (closed 1967) over 50 years ago. They were of developing young plaice from day 30 to 77 and have been stained and cleared and show the bony and pigmented structures (Fig. 2). The bilateral eye placement can be seen in the image of the 30 day specimen lying on its left side by focussing on each eye (Fig. 3).



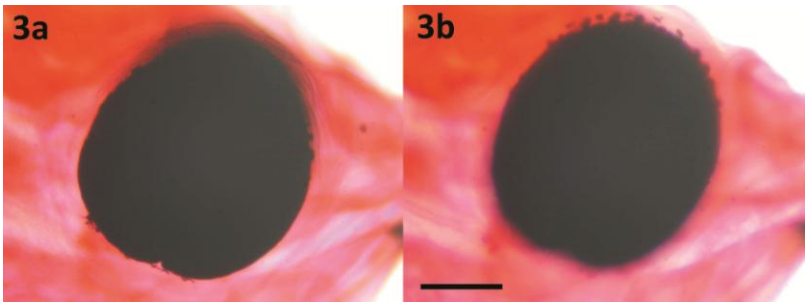


Fig. 2. Photos of set of six Flatters and Garnet whole mount slides of developing young plaice slides viewed on a lightbox showing 30, 36, 51, 57, 70 & 77 days development. Bar 1.5mm

Fig. 3 shows bilaterally symmetric eyes in early development - edge of left eye in focus (a) and right eye in focus (b). Bar 0.15mm

At 51 days, there is one eye still on each side (Fig. 4a). However, by 57 days, the left eye has started migration from the left to the right side (Fig 4b) and by 70 days the migration is complete (Fig. 4c).

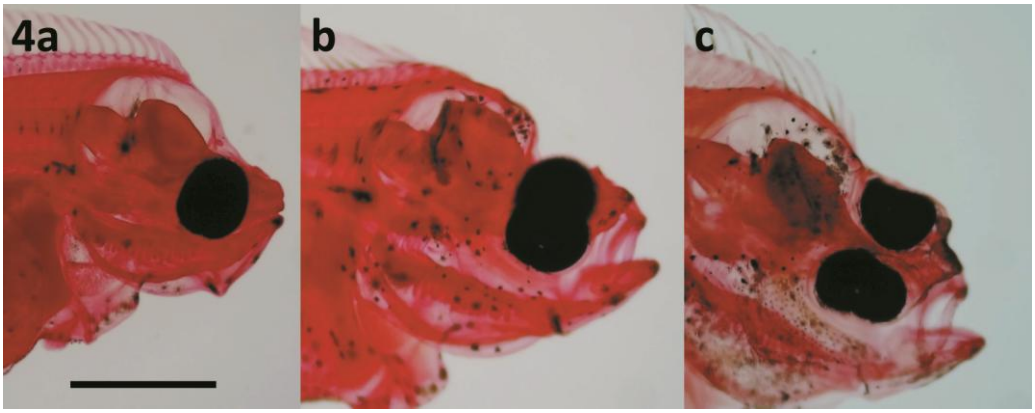


Fig. 4 shows position of eyes at different days. At 51 days (a), eyes bilaterally symmetrical; at 57 days (b), the left eye has started to move & at 70 days (c), both eyes are now on the right side. Bar 1mm.

A Mechanism?

A number of theories have been proposed to explain these morphological changes. Is it a true migration of the eye or is it driven by the asymmetric growth of certain skeletal elements as suggested by Brewster (1987). More recent work (Bao et al, 2011) in which the drug colchicine was injected beneath the left eye prevented the eye movement and development of asymmetric cartilages. Colchicine is a mitotic inhibitor and it suggests that differential proliferation and growth of the adjacent sub-orbital connective tissue of the left eye may be the driver for this process. However, the underlying genetic mechanism is still unknown.

Sidedness and behaviour

The 'eye migration' is potentially an adaptation for benthic living. Studies of the Senegalese sole have shown that a proportion adults can have eyes both left sided or indeed incompletely sided. The behaviour of completely left or completely right-sided eyed soles showed a propensity for staying near the bottom whereas those incompletely sided did not show this as strongly (Xing et al, 2020).

Evolution

There has been controversy over the perceived lack of fossil intermediates showing incomplete sidedness. Indeed Darwin (1906) had difficulty in explaining how intermediate forms could be selected for and was criticised in this regard. However, in a recent study Friedman (2008) demonstrated that, following partial erosion and CT scanning, certain fossils of flatfish ancestors showed evidence of asymmetrical cranial bones which could not be due to deformation and that thus incomplete sidedness was apparent in these extinct species.

Melanophores

The specimens also show clearly the development of melanophores through the melanin pigment they contain which has survived the processing (Fig. 5). Melanophores are one type of pigment cell derived from the neural crest during early development. In the fin region, the melanophore processes are relatively compact (Fig, 5a) but in later stages they are seen to extend along the developing bony rays of the fins (Fig. 5b).

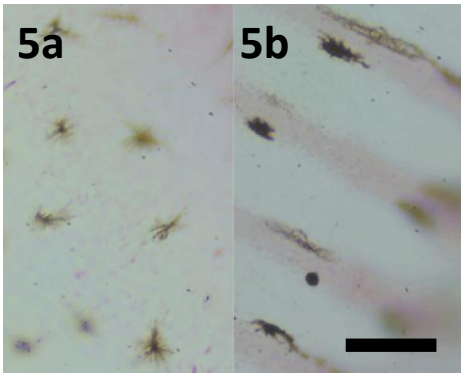


Fig. 5 shows melanophores in the fin region at day 30 (a) which in time become aligned with developing fin rays (b). Bar 0.1mm

References: Bao et al (2011) Dev. Biol. 351: 200-7; Brewster, (1987) Fish Biol. 31: 805-34; Darwin (1906) "Origin of the Species" pp290-4.; Friedman (2008) Nature 454: 209-12; Xing et al (2020) Agricol. Fish. 5: 182-6.