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Spherical Aberration of Crystalline Lens in the Roach, *Rutilus rutilus* L.

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Summary. 1. The lowest optimal value of the relative focal length for paraxial rays ($=f_0/R$, R=radius of crystalline lens) known in fish was found which equalled to 2.192 at 546 nm wave-length.

2. The value of the radius of effective entrance area of crystalline lens, amounting to 0.910 R, was the lowest of those obtained in fish, too.

3. The longitudinal spherical aberration, expressed as the spherical aberration area, S_{LA}, depends parabolically upon the relative focal length for paraxial rays.

4. Similarly to pike and rainbow trout in which species the spherical aberration was studied recently, the distribution of data of the relative focal length for paraxial rays about their optimal value is asymmetric, and therefore the regression curve which represents a relationship between f_0/R and S_{LA} is only a halfparabola (Fig. 3).

5. A comparison to pike and rainbow trout yields that, although the degree of spherical aberration removal in all the species seems to be nearly the same, the differences between various species are remarkable due to a role which is played by the irregularities of both the external shape of crystalline lens and the internal distribution of refractive indices of lenticular tissue. Hence it is assumed that the quality of a monochromatic image formed on the retina of roach is poorer than it might be expected in pike and rainbow trout.

6. A continuing the investigations on spherical aberration of crystalline lens in fish promises good prospects for solving the problem of refractive index distribution and that of resolution angle.

Introduction

The recent investigations of focal length and spherical aberration of crystalline lens on rainbow trout (Sroczyński, 1975a, 1976b) and pike (Sroczyński, 1975b,

1976a) have shown that the relative focal length for paraxial rays, f_{r_0}, expressed as the ratio f_0/R, i.e. similar to the Matthiessen's ratio, and the longitudinal spherical aberration were mutually dependent on each other so that in these two species characteristic values of both the quantities could be established. It gave the evidence that the Matthiessen's ratio, commonly considered to be of 2.55 in teleosts, could not be accepted as a universal value. In the latest paper of this author (1976b) it has been additionally concluded that the focal length of crystalline lens depends strongly on the wave-length of the light source to be used (see also Sivak, 1974, 1975).

Furthermore, it was found that the effective entrance area of the crystalline lens, defined as the cross-section area of a beam of parallel rays which could effectively participate in the image formation, did not coincide with the cross-section of the lens, but it was significantly smaller. The radius of effective entrance area depended on the wave-length of the light used as well (Sroczyński, 1976b).

It is obvious that some progress in focometry of the fish eye can be reached if efforts will be made to enlarge a number of the fish species under investigation in order to replace the Matthiessen's (1882) generalisation of the optical properties of crystalline lens by a new one.

The present study is aimed at obtaining several important optical data of crystalline lens of roach, the species which, contrary to those recently investigated, possesses a round pupil with remarkably narrow aphakic apertures. Hence it might be supposed that the optical properties of crystalline lens would be clearly different from those in both rainbow trout and pike as being equipped with considerable aphakic slits. In particular, some decrease in relative focal length and radius of effective entrance area might be expected.

Methods

The fishes were killed by quick decerebration and their lenses very carefully removed from inside of the eye. The removed lens was submerged in a glass container of a plan-parallel bottom, filled up with the Ringer solution for frogs after Prosser and Brown (1961). The lens was not laid directly on the bottom, but it was put in a hole in an opaque plate placed inside the container.

To begin with measuring procedures, the lens had been carefully examined whether it was free of lenticular parasites. When it did, the measurements of both the focal length for paraxial rays and the zone focal length were carried out as described earlier (Sroczyński, 1975a, 1975b). The mercury-vapour tube was used as monochromatic light source of 546 nm wave-length. The radius of effective entrance area of the lens was estimated as suggested in one of the papers mentioned above (Sroczyński, 1975b).

The meanings of mathematical and physical signs used in this paper are as follows: R=radius of crystalline lens, f_0= focal length for paraxial rays, f= zone focal length. i means the zone distance, i.e., the distance from a given optical axis to a given ray, being parallel to it. f_{r_0} and f_r mean respectively the relative focal length for paraxial rays ($=f_0/R$) and the relative zone focal length, the latter being expressed as F/R. $i_r = i/R$ means the relative zone distance, being numerically equal to the sine of incidence angle α, i.e., the angle formed by the incident ray and the normal at the point of incidence. The longitudinal aberration quotient, LAq, is the ratio f_r/f_{r_0}, being in force at a certain value of i_r. S_{LA} is a denotation for the so called spherical aberration area (Sroczyński, 1975b). Numerically S_{LA} can be computed according to a nonspecific integral (1)