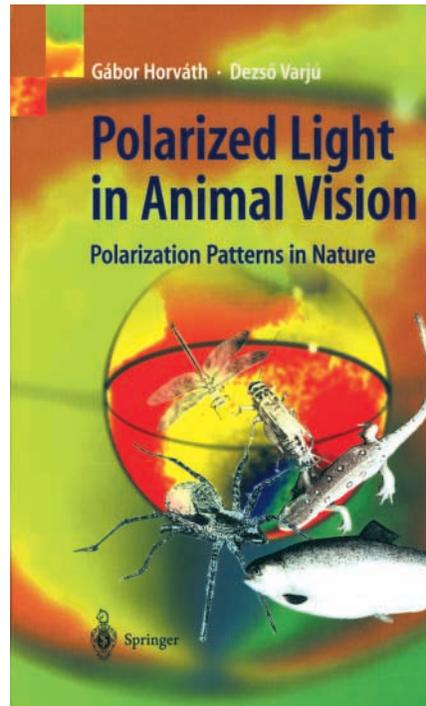


OUT OF SIGHT BUT BROUGHT TO MIND



Polarized Light in Animal Vision: Polarization Patterns in Nature

By Gábor Horváth and Dezső Varjú

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Polarisation is widely regarded as difficult, obscure and, in any case, unimportant, yet nearly all of the natural light we see is partially polarised and many animals both detect this property and exploit it for a variety of purposes. *Polarized Light in Animal Vision: Polarization Patterns in Nature* by Gábor Horváth and Dezső Varjú is an important book that should be examined and kept available for reference by anyone concerned with vision or visual perception in animals.

Failure to face up to the subject seems to have several causes, the first of which is that we, in common with other mammals, are insensitive to polarisation and easily overlook its significance. The 'difficulty' of the subject arises perhaps because it crops up in many fields of physics but is seldom treated as a topic in its own right, and then as a non-intuitive set of equations.

Nevertheless, a fairly comprehensive account of the principles, the various physical effects and their biological implications can be presented without using any maths at all (Pye, 2001).

The present book is a comprehensive treatise, dealing exhaustively and critically with all aspects of the subject. It is divided into three parts of necessarily very unequal length. First, there is a 10-page, single chapter introducing the technology of polarimetry, or the detection and analysis of polarisation; this is effectively the Methods section. Part 2, with 89 pages and 14 chapters, reviews polarised light in the natural environment, as promised in the subtitle. This section covers the reasons why so many creatures need to detect and analyse polarisation and shows how they can exploit it. Finally, Part 3, with 277 pages and 19 chapters, covers the main topic of the book: the detection and analysis of polarisation in animal vision. There are copious figures, nearly 700 references and 16 elaborate colour plates showing environmental phenomena (these are unfortunately grouped after the index, making the latter difficult to find quickly for cross reference).

Seven chapters of Part 2 are devoted to light scattering in the upper atmosphere. The dome of blue sky has a pattern of polarisation centred on the sun, and use of this pattern as a 'sky compass' has considerable advantages over the 'sun compass' for navigation: it works when the sun is obscured by cloud or by forest canopy. Many animals observe it in the near ultraviolet, also invisible to Man, but that is really another, although related, story.

Two chapters (and two more in Part 3) then describe the polarisation produced when light is reflected by any shiny, non-metallic surface and its uses. Conversely, polarised light is also reflected to a degree that depends on the direction of its polarisation. This means that 'it is easy to translate a differentially polarised stimulus into a source of differential brightness' (quoting Martin, 1991), or even of flickering when movement is involved. The scope for pitfalls in visual discrimination tests is obvious although the necessary precautions, reviewed in detail here, are quite elaborate. Less obvious is the fact that reflection can give rise to 'false' colours. The need to decouple true colours from polarisation effects explains the twisting of certain rhabdomes in bees' eyes that effectively neutralises their inherent polarisation sensitivity.

In nature, important reflections come from water where the polarisation both distinguishes between water and other reflective surfaces and also provides an 'artificial horizon' for flight stabilisation. The latter is exploited by dragonflies and the former by many aquatic insects. These are not fooled into mistaking a mirage for standing water but can mistake a paved country lane for a stream suitable for oviposition, or a motor car for a pond. Polarisation sensitivity can also 'break the camouflage' of silvery fishes because, although from most viewing angles they match the colour of the water behind them, the nature of the polarisation is quite different.

A short chapter discusses how under water the combination of sky scattering, reflection from both above and below the surface, and further scattering within the water itself gets quite complicated. The implications for many aquatic creatures are not yet fully clear.

The bulk of the book is about vision. The criteria for polarisation sensitivity were laid out by Waterman and Horch as long ago as 1966 and, in many cases, anatomy alone predicts when they will be met. This is true for insects, arachnids, crustaceans and cephalopod molluscs, all of which are reviewed in detail. They form a large constituency in which parallel microvilli constrain the receptor molecules to be aligned within each retinal cell. In many cases, polarisation sensitivity has been confirmed by behavioural tests or training,

where there are often serious caveats due to naive or careless methodology, or by sensory physiology (neural recording), where the case is usually incontrovertible.

Until a few years ago, it was assumed that vertebrate rods and cones, by their very nature, could not respond differentially to the direction of polarisation. But now suspicion falls on all Classes except the mammals. The evidence in each group is carefully and critically assessed here. There is some evidence in a few species of teleosts, two urodeles and bull frog tadpoles, two lizards and possibly a handful of birds. The examples are as yet few and scattered and the evidence often controversial. There is still no agreed theory about how rods or cones could do it except, as explained here, in the unique eyes of anchovies. Nevertheless, it is a subject that cannot be ignored until further study has clarified things.

This book often gives the impression of having been compiled by assembling a series of separately composed essays. A particular puzzle is the inclusion of a 14-page chapter on sky polarisation during total eclipses of the sun; this seems to have no relevance to any species that (so rarely) experience it and the only justification for inclusion seems to be that it is interesting and that the senior author played an active part in elucidating it.

But the main criticism of the book must be reserved for the publishers, who have served it badly. Although at first sight it

looks very attractive, it soon gives the impression that original typescript was sent to the printers after very little attention. Even the proofreading has been extremely careless, with many glaringly obvious typos remaining. The text is often strained or quaint, where it could so easily have been smoothed by a little benign editorial guidance. It has to be said that where there is awkward syntax, a careful analysis does make the meaning clear but too often the reader is required to make quite unnecessary efforts. The subject is fascinating and it could have been made into a much more enjoyable read by just a little care in production.

Nevertheless, the book is unique, it serves its purpose very thoroughly and is unlikely to be superseded for a long time. It deserves widespread attention, although at the price there may not many personally owned copies around.

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