How do fishes react to total solar eclipses?

Stéphan G. Reebs
Université de Moncton, Canada
2007-2013

People who are interested in the time sense of animals are naturally curious about the reactions of animals to total eclipses of the sun. For the few minutes of totality, when the whole sun disk is obscured by the passing moon, light levels at the surface of the earth are as low as they would be during twilight. If this happens in the middle of the day, a diurnal animal that is out and about will be confronted with contradictory information: the sudden dimming of the light will suggest dusk and tell the animals that it is time to go to bed, but the animal's internal time sense will insist that this is the wrong time of day for sleep. Watching the reaction of diurnal animals during a solar eclipse can tell us whether the move to a sleeping site is triggered more by ambient light levels or by an internal clock.

Published reports indicate that during an eclipse, mammals either keep on going about their normal business (for example, zebras, lions, baboons, ground squirrels, dairy cattle) or appear to be nervous (for example, chimpanzees, horses, hippos).[1] They do not seem to prepare for sleep in any way. We therefore conclude that internal clocks seem to be strongly relied upon. Birds, however, often behave oddly, crowding together and becoming quiet. Some birds have been seen flying to their roost, a pre-sleep behaviour.[2] One observer in Africa reported that waders and herons showed no reaction to a total solar eclipse, but that egrets, oxpeckers, ibis, trumpeter hornbills and geese set off for their roosts. Meanwhile, nocturnal owls and frogs started calling, as if night was starting.[3] Reptiles and insects can also adopt night time behaviour during totality. During a 1991 total eclipse in Mexico, orb weaving spiders were witnessed taking down their webs, as they do every night, and zebra-tailed lizards also seemed to turn in for the "night".[4]

This diversity of reactions does not help us settle the question of whether pre-sleep behaviour is triggered more by light cues or by internal clocks. If all animals remained impassive or just got nervous, as if they knew something was wrong, we could say "Aha! Internal clocks have the upper hand!" On the other hand if all animals went to roost, we'd say "Aha! They rely on light cues only". As it is, it seems that both factors are involved to a certain degree, or that there is variability between species.

Now what about fishes?

I have found only three scientific papers on the behaviour of fishes during solar eclipses. In the first one[5], 2-yr old herring *Clupea harengus* held in an offshore pen were observed during an afternoon eclipse in 1963 in Maine. Some of the fish began schooling near the surface during the total eclipse, as they often do at sunset, but only

some of the fish did this. The response was judged to be "not strong" but it must be said that totality lasted only a minute or so. In the second study[6], three freshwater species of air breathers (the cuchia *Amphipnous cuchia*, the climbing perch *Anabas testudineus*, and the banded gourami *Colisa fasciata*) were observed in captivity during a 1980 solar eclipse in India. All three species almost stopped gulping air, became sluggish, and settled to the bottom. *A. cuchia* and *A. testudineus* also changed colour and turned blackish. All this is typical night time behaviour. In the third study[7], various reef fishes were followed in the wild during a 1998 total solar eclipse at Pinta Island, in the Galapagos. As the eclipse progressed, the fish descended from the water column and retreated to crevices within the reef, where they remained hidden for the duration of totality. This is typical twilight and night time behaviour. The fish did not appear to go to sleep however, for they resumed their normal activities within three minutes of the end of totality. The only diurnal species that did not exhibit night time behaviour during totality was the surgeonfish *Prionurus laticlavius*, which stopped grazing and formed schools that swam erratically with apparent alarm. Altogether, the latest case notwithstanding, these observations suggest that light intensity is fairly important in eliciting twilight and night time behaviour.

It is possible to study the response of fish to a midday dimming of the lights in the laboratory. But first we need to identify a behaviour that is typical of dusk or night time, and easy to measure. One such behaviour is fry-retrieving in cichlids. Many species of cichlids keep watch over their brood of free-swimming fry. When night approaches the parents excavate a pit in the gravel of their aquarium and then they seek their fry, catch two or three at a time in their mouth, return to the pit, and unceremoniously spit the fry into the pit. They keep doing this until all the fry are retrieved. Thus when night finally arrives the fry are gathered in one place so that the parents can easily guard them. Usually parents start retrieving just before nightfall, and if they are not done by the time all lights go off they continue retrieving in complete darkness. (How they manage to find their young and return to the pit in the dark is an interesting question, as yet unanswered. It could be addressed with the help of infra-red lighting and infra-red goggles to observe the retrieving fish).

In one study of this behaviour, I installed parental convict cichlids in tanks under a regime of 12 h of lights-on and 12 h of lights-off. When I dimmed the lights 15 minutes before the normal time of lights-off, my cichlids busily retrieved their fry. But when I dimmed the lights in the middle of the day, or in the middle of the afternoon, they did not retrieve. It looked as if their internal clock told them that a midday dimming could not be twilight. However, there were limits: when I completely turned off the lights in the middle the day, then the parents started to retrieve their fry. Fry-retrieving seems to be partly influenced by light levels, and partly by an internal clock that tells the fish when it should be done.[8]

And with this we have reached the same conclusion as with the observations of other animals during eclipses. It is not black and white.

[1] Ozbey, O., Aysondu, M.H., Ozer, H., Simsek, U.G., 2004, The effects of a solar eclipse on animal behaviour, Turk Veterinerlik ve Hayvancik Dergisi 28: 55-61; Branch, J.E. Gust, D.A., 2005, Effect of solar eclipse on the behavior of a captive group of chimpanzees (*Pan troglodytes*), American Journal of Primatology 11: 367-373; Gil-Burmann, C., Beltrami, M., 2003, Effect of solar eclipse on the behavior of a captive group of hamadryas baboons (*Paplo hamadryas*), Zoo Biology 22: 299-303; Rutter, S.M., Tainton, V., Champion, R.A., Le Grice, P., 2002, The effect of a total solar eclipse on the grazing behaviour of dairy cattle, Applied Animal Behaviour Science 79: 273-283; Spoelstra, K., Strijkstra, A.M., Daan, S., 2000, Ground squirrel activity during the solar eclipse of August 11, 1999, Zeitschrift fur Säugetierkunde 65: 307-308; Murdin, P., 2001, Effects of the 2001 total solar eclipse on African wildlife, Astronomy & Geophysics 42 (4): 4.04.

[2] Tramer, E.J., 2000, Bird behavior during a total solar eclipse, Wilson Bulletin 112: 431-432; Maccarone, A.D., 1997, Directions of foraging flights by wading birds during an annular eclipse, Colonial Waterbirds 20: 537-539.

[3] Murdin, P., 2001, Effects of the 2001 total solar eclipse on African wildlife, Astronomy & Geophysics 42 (4): 4.04.

[4] Uetz, G.W., Hieber, C.S., Jakob, E.M., Wilcox, R.S., Kroeger, D., McCrate, A., 1994, Behavior of colonial orb-weaving spiders during a solar eclipse, Ethology 96: 24-32; Ortegarubio, A., Galinatessaro, P., Alvarezcardenas, S., 1994, Behavior of the zebra-tailed lizard during a total solar eclipse, Texas Journal of Science 46: 121-126.

[5] Skud, B.E., 1967, Responses of marine organisms during the solar eclipse of July 1963, Fishery Bulletin of the Fish and Wildlife Service 66: 259-271.

[6] Pandey, K., Shukla, J.P., 1982, Behavioural studies of freshwater fishes during a solar eclipse, Environmental Biology of Fishes 7: 63-64.

[7] Jennings, S., Bustamante, R.H., Collins, K., Mallinson, J., 1998, Reef fish behaviour during a total solar eclipse at Pinta Island, Galapagos, Journal of Fish Biology 53: 683-686.

[8] Reebs, S.G., 1994, The anticipation of night by fry-retrieving convict cichlids, Animal Behaviour 48, 89-95. Convict cichlids also fan their eggs during a midday pulse of darkness, just as they do at night, by swimming along the egg batch, belly facing the eggs, both pectoral fins contributing to water movement; see: Reebs, S.G., and Colgan, P.W., 1991, Nocturnal care of eggs and circadian rhythms of fanning activity in two normally diurnal cichlid fishes, *Cichlasoma nigrofasciatum* and *Herotilapia multispinosa*, Animal Behaviour 41, 303-311.