The Strange Case of the New Haven Oysters

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A persistent claim that oysters can sense where the moon is, even when they are indoors, rests on a single, inconclusive experiment.

The inhabitants of our seashores are often made aware of two great timekeepers in the sky. The sun provides us all with a 24-hour cycle of light and heat, but shore dwellers also need to follow the ebb and flow of tides, the average time from one high tide to the next being set by the moon at 12 hours and 25 minutes. Many species have adapted their behavior to accommodate these natural rhythms, and the resulting biological cycles form part of a well-established field of study. (See, for example, Wheeler 1990.)

One interesting aspect is the way these cycles can persist for plants and animals moved to artificially constant surroundings. The question arises whether they mark time with an internal clock or whether they can still sense the sun and moon after the obvious clues have been suppressed. If the latter is true, and animals can tune into our local cosmos via very subtle signals, some versions of astrology might gain a certain credibility.

Tidal rhythms provide a simpler test case than the more common daily rhythms, as it is much easier to isolate something from the tides than it is from the daily round of heat, light, and general bustle. If a creature with a tidal rhythm were transported to a new location and found to adjust its rhythm to the times appropriate locally without being exposed to tidal water, this would be good evidence for the "tuning in" hypothesis.

Known Lunar Influences

There need be nothing paranormal about these signals, as the moon causes gravitational and magnetic variations with the same periodicity as the tides. They are monitored by geophysicsts, so subtle clues are certainly available to any displaced shore life. But is it likely that living creatures could sense them directly?

The only measurable gravitational effect causes a small change in weight. When the moon is on the horizon, at moonrise and moonset, everything tends to weigh a little more than at times of lunar transit, when the moon is highest in the sky or furthest below the horizon.[1] If this is not apparent from your dieting chart, it is because the maximum possible variation is just 0.000035 percent. For a large person this might amount to 35 milligrams—less than the weight of a small postage stamp. Specialized instruments can measure such a change, but only when they are carefully protected from vibration and drafts. This is because weighing machines (and gravity sensors) can't help acting also as acceleration meters, so that any movement registers as a change in weight. Just try weighing yourself while waving your arms around. In the same way, even if an animal possessed an amazingly sensitive gravity sensor, the tiny lunar effect would be utterly swamped by any small movements it made.

The moon's effect on the earth's magnetic field is even more elusive, as it is only a small addition to much larger variations, mainly due to the sun. The moon's effect is only apparent after analyzing several weeks' readings so that day-to-day changes in the solar cycle can be averaged out, and then only when sunspot activity is low (Chapman and Bartels 1940). It would be hopeless to try to track the moon with a compass.

From what we know, then, it would be very curious if an animal could sense a tidal rhythm without feeling the tides. Maybe it's not impossible, but the evidence in favor would need to be pretty persuasive. So what is the evidence? Whenever such a claim is made, one experiment stands out as the least ambiguous and the most quoted, respectfully mentioned by Michel Gauquelin (1967:118), Culver and Ianna (1988:183), and the *Encyclopaedia Britannica* (1974)—that of the New Haven oysters.

The Oysters Experiment

The experiment was done in 1954 by Frank A. Brown of Northwestern University (Brown 1954). (The same results, without mention of any follow-up experiments, are presented in Brown et al. 1970). A batch of oysters was taken from the Atlantic Ocean off New Haven, Connecticut. Then, after careful packing and a few days' wait they were taken 800 miles inland to Evanston, Illinois, near Chicago. Here they were kept alive and well in seawater tanks in a photographic darkroom. To monitor their activity they were connected by a spring and thread arrangement to a pen recorder; this automatically charted when the oysters were open or closed over the next 46 days.

The data were analyzed for both solar day (24 hours) and lunar day (24 hours and 51 minutes) periodicity. The solar day rhythm does not concern us here, but in order to avoid confusion between it and the lunar rhythm it was necessary to analyze 15 days' worth of data at a time—it is only possible to see the lunar rhythm as an average for a 15-day period. The 46-day record could then show how the oysters' activity varied through the lunar day over three consecutive 15-day periods, the first

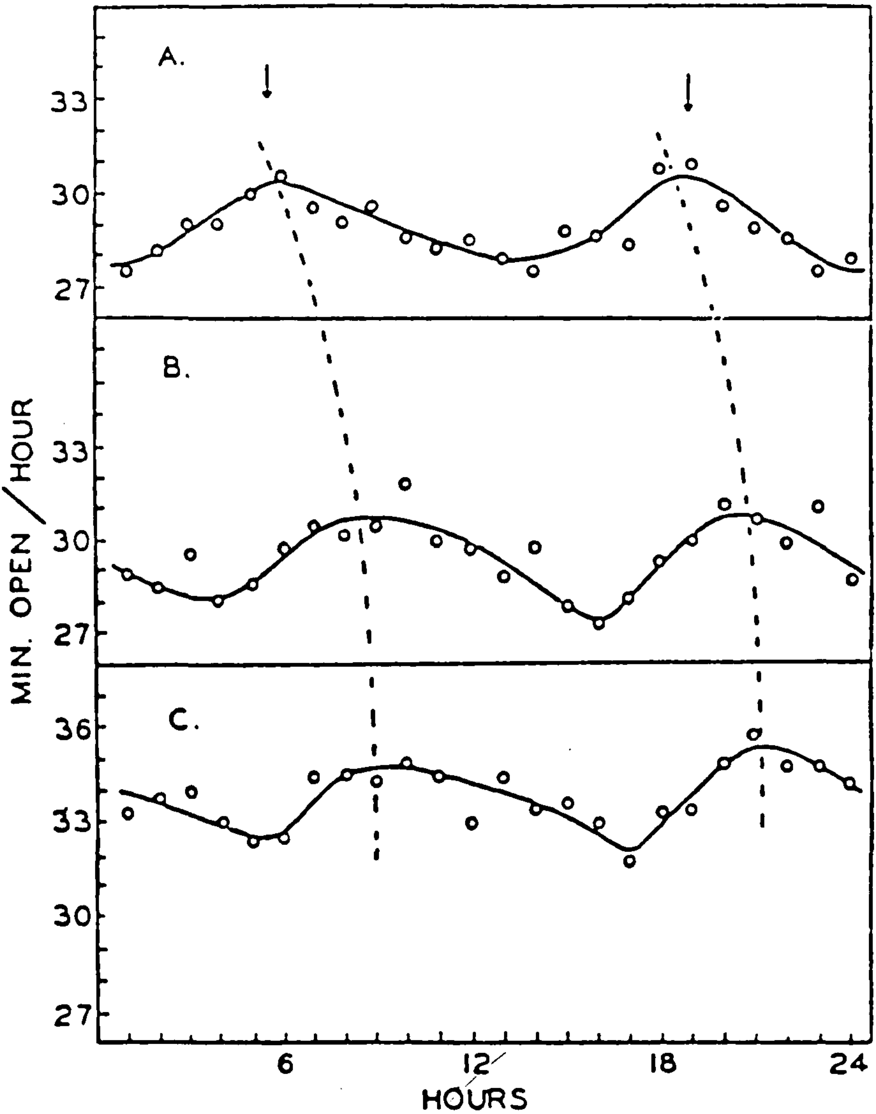

Figure 1. The oysters' activity rhythms through the lunar day, as shown by Brown (1954). The three graphs show the average behavior over consecutive 15-day periods in a controlled environment.

day's data being discarded.

All the lunar rhythm information is contained in just three graphs, and these are shown in Figure 1. The results appear to show something very remarkable. In the first period, there was a small but definite tidal cycle—two tides per lunar day—the peaks of activity coinciding, we are told, with times of high tide at New Haven. The rhythm continued in the second and third periods, but the peaks had shifted to times about three hours later. Now, we are told, they coincided with the times of lunar transit at Evanston, their new loca-

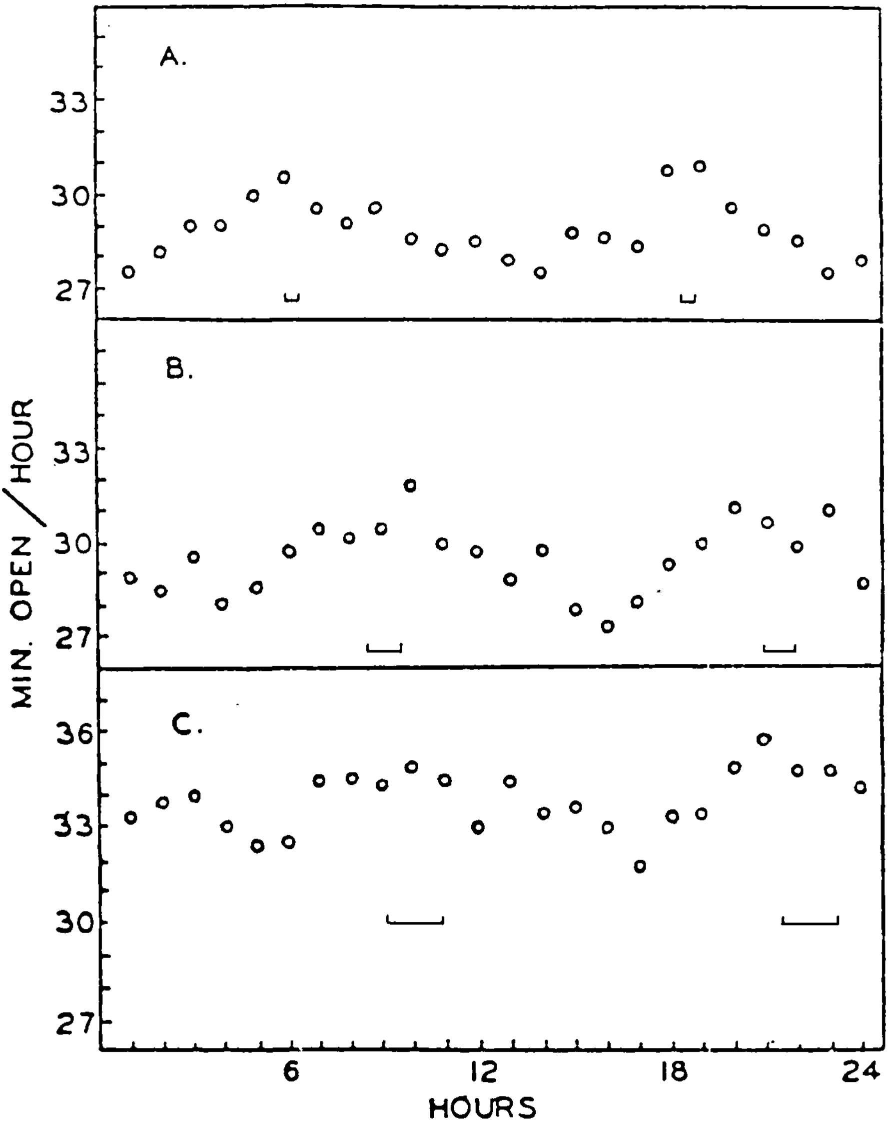

Figure 2. The same data as Figure 1 without the guidelines. The new lines are the author's estimates of the times of peak activity, assuming the activity has tidal periodicity.

tion. Here at last is the nub of the matter. Deprived of their home tides, the oysters seem to have synchronized their activity with the movements of the moon at their new location. How did these oysters in their dimly lit water tanks sense where the moon was?

A Closer Look at the Data

Brown's observation that the oysters had synchronized their activity to the local lunar transits was reached purely by inspection of the graphs in Figure 1. There was no further analysis of this data, nor were there other sets of data in support. Before we guess what kind of moon detector an oyster might keep up its sleeve, then, it is well worth checking this evidence in more detail.

First, consider the solid lines drawn through the results. They are not part of the data; nor are they the results of a theoretical model. They are instead what are known in the trade as "guides to the eye." In practice, this means they are drawn somewhere between where the data lie and where the author would like them to be, possibly giving a misleading impression. Figure 2 shows the same data, without the guiding lines. Readers are invited to fit a tidal rhythm curve to each set of data to obtain the times of peak activity, remembering that the peaks should be 12.4 hours apart. My own attempts to locate the peaks produced the ranges of times indicated. The uncertainties in the data already make it a little rash to reach radical conclusions.

Now the implication in the paper is that the time difference between the arrows in the first set of data and the dotted lines in the second and third sets is just that between high tide at New Haven and lunar transit at Evanston. The paper omits telling us just how long this really is, but it is a fairly simple matter to look it up in suitable almanacs. The average time difference is in fact 2.2 hours. Compared with my best estimate from the data of 3.5 hours, or even the values indicated in the paper (about 2.2 hours for the later peak but 3.3 for the earlier one), the experimental result is hardly a convincing match.

It should be clear that the evidence for these oysters' sensing the moon is weak. Even so it might still seem suggestive—after all, the peaks have moved in the right direction by an amount not altogether different from the one prescribed. But there are other reasons the lunar link is unlikely.

Do Oysters Read Bad Textbooks?

One big problem is that there is little point in this exercise from the oysters' point of view. If the oysters were able to sense the moon at New Haven, they would have found that high tides occurred, on average, an hour and a quarter before lunar transit. It would then be logical for them to expect a similar difference at Evanston, so that the expected shift in the activity peaks would be just one hour.

There is no good reason to expect high tides to occur at lunar transit. Only naive versions of tidal theory suggest that there is—a look at a few tide tables shows that the oceans have other ideas. Why should the oysters want to synchronize with lunar transits in the first place?

An Alternative Explanation

The shift in the activity peaks could easily have a quite different explanation—the oysters' clocks running slightly slow. If the oysters, in the absence of regulation by tides, let their activity period lengthen by a few minutes, the peaks would move on a little each lunar day. Averaging over 15 days would mean that the second set of data differed from the first in just the way that was observed. The oysters' average activity period would have needed to be about 12 hours and 31 minutes—6 minutes too long. The "slow clock" hypothesis should be distinguished from the "moon tuning" hypothesis by the third set of data: in the former case, the peaks should keep moving; in the latter, they should remain where they are. Alas, the third set isn't clear enough to settle the question—there seems to be a small extra shift, but the cycle is less pronounced and harder to pin down.

It is worth mentioning that if the lunar cycle is both slow and dying away, this extra shift should be smaller than the previous one. No one could seriously point to that third set of data as proof of anything unusual.

So the case of the New Haven oysters turns out to be distinctly fishy and probably not very strange. While it is high time the matter was resolved by more convincing experiments,[2] the real mystery is how the dubious conclusion that oysters can set their clocks by the passing of the moon has found a durable place in scientific lore.

Notes

1. The forces responsible are usually called "the tide generating forces." Their effect on gravity is slightly enhanced because they also distort the shape of the earth (Cook 1969). To be pedantic, there are also small sideways forces that swing from side to side with the tidal period, so that the vertical changes direction by around 0.00001°. These are crucial to the effect on the oceans; but like the weight change, they would not be noticed by an animal that moved in the course of the day.

2. The most important aim would be to reduce the scatter in the results by using a larger sample. It would also be valuable to have a control set that was not moved and a third set that was moved in an easterly direction. This last set, if it retimed itself to lunar transits, would require the oysters' clocks to run fast. This would be much more unusual than their clocks running slow.

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Science Cannot Be Mechanized

[Karl] Popper's teaching . . . stresses that science is a creative subject. . . . The generation of science cannot be mechanized. There is no possibility of defining a "scientific method," a prescription that anybody can follow and "make science." Scientists have to be people of flesh and blood, of passion and drive, of daring and courage.

—Sir Hermann Bondi, "The Philosopher of Science" (a tribute to Karl Popper), *Nature*, 358:363, July 30, 1992