to be a full order of magnitude larger in longitude than in latitude, whereas the ratio required here is only about 5 : 2.

To explain Galileo's residual as an ephemeris error, an unknown and rather pathological perturbation must be invoked. As Kowal and Drake state, "... it is surprising that the 'incorrect' ephemeris position still lies on the same straight line from Jupiter and the star".

One must seriously question Galileo's drawing as (1) Galileo was not interested in "extraneous objects", and (2) Galileo used a dashed line to connect stars 'a' and 'b' as he did in other cases where he wished to indicate direction only, not distance.

It is true that other pre-1900 observations of Uranus and Neptune do not seem to be consistent with those of the modern era. However, these discrepancies could be the result of observational errors, as most probably is the case here with Galileo.

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1. Kowal, C. T. & Drake, S. *Nature* **287**, 311–313 (1980).

KOWAL REPLIES—Although I am pleased to see these responses to our letter, I feel that an adequate assessment of Galileo's accuracy requires a much more rigorous analysis. In particular, Rawlins' assumption of a circular orbit for an 'outside' perturber is likely to be a gross oversimplification, as it would be in the case of Pluto.

Standish's reasons for questioning Galileo's drawing are not valid, for the following reasons:

Galileo clearly was interested in this "extraneous object" because he specifically noted its relative motion. Furthermore, he drew a linear scale in that diagram for the very first time. It would be quite surprising if he did not use that scale when drawing Neptune's position.

Galileo often used dashed lines, even when indicating exact distances; for example, in the drawings of SAO119234 on 25–27 January. It is certainly true, however, that Galileo's drawings are far less accurate than his measurements.

Standish's statement that the requisite perturbation in latitude was "easily produced" in his numerical experiments is suggestive. Again, Pluto shows that "pathological" cases do exist.

In any case, I hope that the question of Galileo's accuracy will not obscure the central points of our paper. These are:

We have established that Galileo observed Neptune, and noted its motion, 234 yr before Neptune was discovered.

We have demonstrated a new technique for finding other pre-discovery observations of Neptune. In particular, we should search for observations of the 1702 occultation.

Obviously, I would not insist that Galileo's drawing is accurate. If more pre-discovery observations of Neptune are found, we will be able to make a more useful assessment of the Neptune residuals. Until then, I must maintain that there is a "strong possibility" that the theory of Neptune's orbit needs to be revised; not only because of the Galileo observation, but also because of the previously known residuals.

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Does spider feeding behaviour optimize dietary essential amino acid composition?

GREENSTONE[1] has concluded that the spider *Pardosa ramulosa* takes a non-random mixture of its three main prey and that this mixture optimizes the proportions of the essential amino acids in the diet. For statistical reasons, these conclusions are invalid.

The spiders fall into eight classes, which Greenstone regarded as the cells of a $2\times2\times2$ contingency table, according to whether they were serologically positive or negative for each of the three main prey. The overall proportion of triple negatives is about 25%, from which 3% must be (and was) removed to allow for moulting animals, which do not feed. If the average number of serologically potent prey in the gut is one, the remaining proportion of triple negatives is consistent with Greenstone's view that about 20% of the diet is made up of species other than the three main ones. However, some guts contain at least three prey individuals, as they are positive for all three species. Thus, there must be considerable spread around the mean, with many spiders containing no prey and some containing many.

As a result, the contingency tables may show large values of 'χ^2' even if the recent occurrence of one species in the diet has no effect on the relative probabilities of the spider eating another member of the same species or a member of another species.

This may be demonstrated by a simple example. Suppose we have a population comprising N_0 animals with no prey individuals in the gut, N_1 with one and N_2 with two. Further suppose that the prey are of two species, which occur in the overall proportions of p and q in the diet. Finally, suppose that these proportions are the same among the animals with one prey individual in the gut as among those with two prey individuals in the gut. Among the latter, if the presence of one species in the gut is unrelated to the presence of the other, then the proportions of individuals with two individuals of the same species in the gut are p^2 and q^2; a proportion $2pq$ will have one prey of each species in the gut. Thus, in the population as a whole, there would be the following numbers of individuals serologically positive or negative for the two species:

$$\text{A}-,\text{B}-:\quad a = N_0$$
$$\text{A}+,\text{B}-:\quad b = pN_1 + p^2N_2$$
$$\text{A}-,\text{B}+:\quad c = qN_1 + q^2N_2$$
$$\text{A}+,\text{B}+:\quad d = 2pqN_2$$

If we treat these four classes as the cells of a 2×2 contingency table, our 'expectation' is that $ad - bc = 0$. Except for particular sets of parameter values this expectation is clearly false. In other words, the calculation of χ^2 does not provide a test of the hypothesis that the probability of consumption of each species is independent of whether or not the spider has recently consumed a member of that species.

An alternative explanation of the high proportion of triple negatives is that the proportion of the diet made up by species other than the main three is higher than 20%. If so, it scarcely seems right to ignore these other species when working out the dietary composition.

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1. Greenstone, M. H. *Nature* **282**, 501–503 (1979).

GREENSTONE REPLIES—In all phases of human endeavour it is important to mind one's p's and q's; in statistics one must also ask whether they are relevant to the question at hand. Greenwood's exposition of the prey item makeup of the serologically positive stomach classes is correct and self-evident. However, only the values of a, b, c and d, and not their underlying constituents, are relevant to the test of association.

Let us consider a hypothetical human dietary example. Suppose a cafeteria serves only beans and rice and gives each diner the choice of one, two or no scoops of each. After a large sample of diners has passed through the line we tabulate the contents of their plates. If we wish to know whether the average diner is receiving a balanced diet we must add up all of the scoops of beans and rice so as to compute Greenwood's p and q, and then apply them to what we know about human nutritional requirements and the nutrient compositions of beans and rice; this is analogous to my use of the data in Tables 2 and 3 of the original paper[1] to compute the proportions of the essential amino acids in the spiders' diets.

If, however, we wish to know whether beans and rice are significantly *associated* in the diet, we need only concern

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