herbarium to allow subsequent researchers to evaluate statements made in the literature about the characteristics of a given taxon. The editors of various scientific journals should also ensure that all authors cite the accession number/numbers of their voucher specimens and the herbaria where deposited. While this enhances the value of scientific findings, at the same time it strengthens the justification of the importance of the herbaria.

Thus, herbaria are helpful to both classical and experimental biologists not only for obtaining the basic data on plants but in also serving as a caretaker of the voucher specimens on which tremendous amount of literature accumulates. In view of this, are we unjustified in demanding for allocation of some percentage of funds from all research projects as service charge for development and maintenance of herbaria? It is also certainly unwise to score out the herbaria and taxonomic researches as establishments of no economic gains as the present trend goes.

National herbaria like the Central National Herbarium, Herbarium of the Forest Research Institute, Dehra Dun, and the Herbarium of the National Botanical Research Institute, Lucknow are critically endangered due to lack of sufficient trained manpower, facility and even due recognition by the so-called experimentalists. With the overgrowth of several modern disciplines the importance of herbaria has faded, resulting in such a damage that would be felt in the immediate coming years. Khoshoo[1] has rightly pointed out that taxonomists are a 'vanishing tribe' among the biologists and are greatly overshadowed by the so-called and more often second-rate biotechnologists and environmentalists.

Herbaria require large buildings and staff for curation of vast collections, laboratories for associated researches and funds for continuous explorations for enriching the herbaria, particularly in a developing country like India where the coverage of holdings is incomplete. The knowledge of variation within species is another aspect which is very limited. But the increasing financial squeeze and thoughtless prioritization of research programmes have greatly affected the overall health of the herbaria in the country. Often comments from scientists state that the massive collections in the herbaria be dispensed with and only few sample collections and type specimens be maintained[2]. There is therefore, an urgent need to educate the policy makers, the experimental biologists, and other key persons who matter much for development of herbaria in the country about the 'essentiality' of a herbarium.

A rational economic basis for maintenance and furtherance of herbarium research must consider the fact that botanists with all their concerted efforts have known only 1/10th of what exists in our tropical forests and still less is known of the economic utility of those species which are recorded. Infraspecific biodiversity and population variation of the rich tropical flora are little understood. But certainly maintaining and enriching a herbarium is expensive. A strict monitoring of the quality of the incoming collections and zones from where they come is essential in order to maintain the quality and not the size of the herbarium. More than one herbaria if any, within a city or town (e.g. Dehra Dun, Lucknow) can be considered for merging in view of the increasing cost of maintenance, manpower, space on buildings, etc., rather than 'killing' a herbarium due to wrong policies and apathy towards such classical subjects upon which many future solutions depend.

1. Khoshoo, T. N., *Curr. Sci.*, 1995, **69**, 19–17.
2. Clifford, H. T., Rogers, R. W. and Dettmann, M. E., *Nature*, 1990, **346**, 602.

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SCIENTIFIC CORRESPONDENCE

The academy fellowship problem

The problem

A science academy elects new fellows every year. In order to improve the overall quality of its fellowship, it decides to impose a new criterion that every new fellow elected shall be better than the median level of the existing population of fellows*. How fast will the quality of the fellowship improve?

*This criterion was proposed for the Indian Academy of Sciences by Professor V Radhakrishnan in the mid-seventies.

A toy model

The above problem needs to be recast in a quantitative form. It is difficult to quantify 'quality' of a scientist but suppose in a toy model we use a variable x to measure it on a scale ranging from 0 to 1, with 1 being the mark of perfection. Let us measure the time in years with $t = 0$ denoting a starting year when this criterion is announced to be implemented in all subsequent years. Let $f_n(x)$ denote the cumulative quality distribution of fellowship in the year $t = n$, $n = 0, 1, 2, \ldots$ In the starting year the total number of fellows was N_0, say and suppose that by statutes, every year N fellows must be elected.

Denote by M_n the median of the distribution $f_n(x)$. Thus

$$f_n(M_n) = \frac{1}{2} f_n(1) = \frac{1}{2}(N_0 + nN), \qquad (1)$$

and while electing in year n, care is taken that all new additions shall have the quality parameter $x > M_{n-1}$. Improvement in quality will then be indicated by how the median M_n steadily increases in value year by year.

We still need to specify the quality distribution of the pool of scientists from which the new fellows are chosen. We denote by $g(x)$ the cumulative probability that a scientist selected at random from this pool will not have the quality parameter exceeding x. Thus

$$g(0) = 0, \qquad g(1) = 1. \tag{2}$$

In this toy model we have ignored the reduction in the total population of fellows due to death or resignation (or even eviction).

With these specifications we can now pose the question more precisely: Given the functions $f_0(x)$ and $g(x)$, how does M_n increase with n?

Solution

First note that for $t = n$, the median criterion implies

$$f_n(x) = f_{n-1}(x) \text{ for } x < M_{n-1}. \tag{3}$$

For $x \geq M_{n-1}$, there will be addition of N fellows whose distribution will be assumed to be proportional to the function $g(x)$ over $M_{n-1} \leq x \leq 1$. Therefore, we have for $x \geq M_{n-1}$

$$f_n(x) = f_{n-1}(x) + N\,\frac{g(x) - g(M_{n-1})}{1 - g(M_{n-1})}. \tag{4}$$

Since for the distribution $f_n(x)$ there are $\frac{1}{2}(N_0 + nN)$ members with $x < M_n$, these comprise of the $\frac{1}{2}\{N_0 + (n-1)N\}$ members with $x < M_{n-1}$ together with the number $f_{n-1}(M_n) - f_{n-1}(M_{n-1})$ from the earlier distribution and the new addition as per (4) above. Carrying out this book-keeping we have

$$f_{n-1}(M_n) - f_{n-1}(M_{n-1}) + N\,\frac{g(M_n) - g(M_{n-1})}{1 - g(M_{n-1})} = \frac{1}{2}N. \tag{5}$$

Next we consider the number $f_{n-1}(M_n) - f_{n-1}(M_{n-1})$ which has arisen from steady addition to $f_0(M_n) - f_0(M_{n-1})$ over all the preceding years following the rule (4). Therefore,

$$f_{n-1}(M_n) - f_{n-1}(M_{n-1}) = N\sum_{r=1}^{n-1}\frac{g(M_n) - g(M_{n-1})}{1 - g(M_{r-1})} + f_0(M_n) - f_0(M_{n-1}). \tag{6}$$

From (5) and (6) we have the final relation

$$f_0(M_n) - f_0(M_{n-1}) + N\{g(M_n) - g(M_{n-1})\} \times \sum_{r=1}^{n}\frac{1}{1 - g(M_{r-1})} = \frac{1}{2}N. \tag{7}$$

This iterative relation determines the sequence $\{M_n\}$ in a step by step fashion starting with M_0, since for determining M_n we have all other quantities known from the preceding application of this relation.

A simple example

We will illustrate the above solution with a simple example in which both the initial distribution and the general population distribution are uniform with respect to the attribute x. In this case

$$f_0(x) = N_0 x, \qquad g(x) = x. \tag{8}$$

and the relation (7) gives

$$M_n = M_{n-1} + \frac{1}{2\sum_{r=1}^{n}\frac{1}{1 - M_{r-1}} + \frac{2N_0}{N}}. \tag{9}$$

Even with this simple example we cannot find a solution in closed form, but Figure 1 illustrates the march of M_n for $0 \leq n \leq 25$, $N_0 = 500$ and $N = 20$ obtained by numerical methods. The median value rises from 0.5 to 0.75 over twenty-five years.

The continuum version

The solution, however, becomes tractable even for the general case if we modify the problem by having a continuous input of fellows at all times instead of the discrete annual input. A simple analysis shows that the relation (7) is changed to an integro-differential equation

$$\left(\frac{dM}{dt}\right)^{-1} = \frac{2}{N}\frac{\partial f(x,t)}{\partial x}\bigg|_{x=M(t),\,t_0} + 2\int_0^t \frac{g'(M(t_1))\,dt_1}{\{1 - g(M(t_1))\}}, \tag{10}$$

where the prime denotes derivative with respect to the argument. Here the rate of

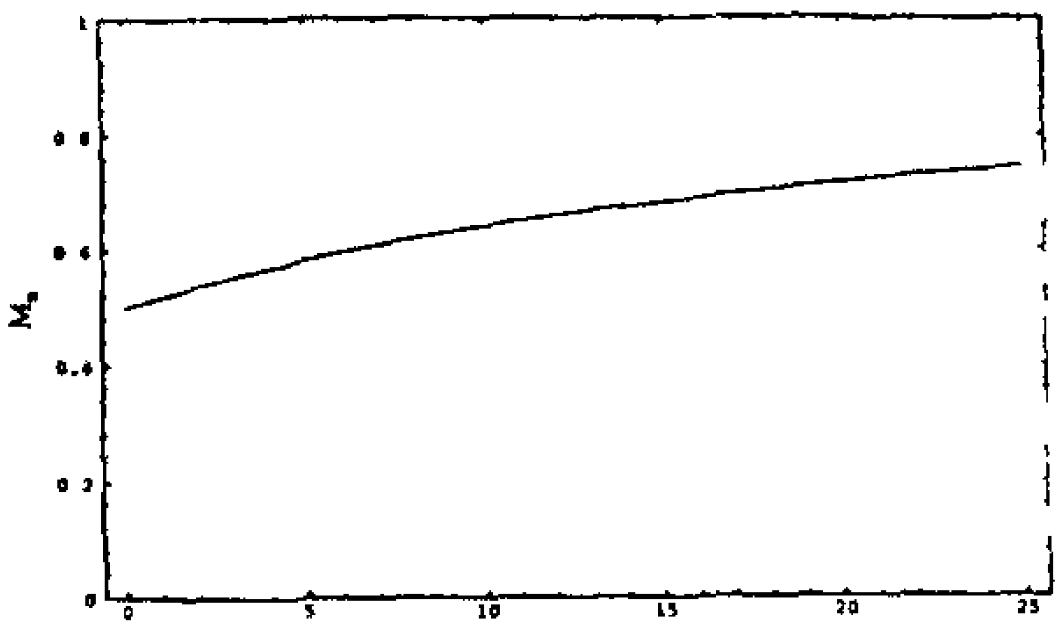

Figure 1. The figure shows how the median value of the fellowship quality improves with successive elections over 25 years in the simple toy model.

fellowship input is N, that is $N\delta t$ to be added in a time interval δt. Also, the fellowship distribution at time t is now denoted by $f(x, t)$ and its median by $M(t)$.

The equation (10) is solvable in closed form and in the general case we have

$$\frac{dt}{dM} = \frac{2}{\{1 - g(M)\}^2} \times \left[\int_{M(0)}^{M(t)} \alpha'(M)\{1 - g(M)\}^2\,dM + A\right], \tag{11}$$

$$\alpha(M) = \frac{1}{N}\frac{\partial f(x,t)}{\partial t}\bigg|_{x=M,\,t=0}, \tag{12}$$

where A is a constant of integration. For the simple case of uniform distributions discussed earlier the solution is very simple:

$$M(t) = \frac{1}{2}\cdot\frac{1 + (2tN/N_0)}{1 + (tN/N_0)}, \tag{13}$$

and it fits the curve of Figure 1 very well. In fact an approximate discrete solution based on equation (13), viz.

$$M_n = 1 - \frac{1}{2}(1 + nN/N_0)^{-1} \tag{14}$$

satisfies the iterative relation (7) with a good approximation.

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