A History of the Ecological Sciences, Part 15: The Precocious Origins of Human and Animal Demography and Statistics in the 1600s

In antiquity there had been a slight interest in human demography and a more definite interest in animal demography, but no continuous tradition of investigation developed (Egerton 1968, 1975, 2001*a*, *b*). During the 1600s interest in human demography arose, and that revived interest in animal demography. The first theoretical problem came from the Old Testament and concerned the longevity and consequent population growth of the Biblical patriarchs (Egerton 1966). Genesis 5 claims that the early descendants of Adam lived over 500 years, and later, according to Genesis 6, God reduced human age to 120 years, and still later to about 70 years (Psalm 90:10). There was some wonderment about why the ages had first been so long and later reduced, but the question that provoked calculations was the rate at which the earth had been populated by the descendants of Adam and Eve, and then later by the descendants of Noah.

A French Jesuit theologian, Denis Petau (1583–1652), discussed this puzzle in his widely reprinted work, *Opus de doctrina temporum* (1627). The Assyrian civilization supposedly began only about 153 years after the Flood of Noah, and yet they had a large and populous empire shortly thereafter, and they encountered other populous nations in war. Apparently some of Petau's predecessors had not had his confidence in human reproductive capacity, for they had resorted to the postulations that early people began procreating at age 13 or younger, and that twin or triplet births were frequent. While rejecting these assumptions, his own arbitrary assumptions were that one or two lines of Noah's descendants would be all males and that another line would produce enough females to provide them with mates. He also postulated that procreation began at age 17 and that each man would have eight sons by age 24. Since he also assumed there would be no mortality before age 24, he increased the number of children every generation by a multiple of 8. His computation of the number of children born every 23 years after the Flood (but beginning in the eighth year after it) for 285 years totaled 623,612,358,728. His calculation for year 215 is incorrect, which throws off the subsequent calculations, but the correct figures would not have altered his conclusion that the potential for human population growth could have rapidly filled the earth if there was no mortality before age 24, and if everyone had children (Petau 1757:Book .9, Chapter 14, Volume 2, p.18, Egerton 1967:46).

Petau's discussion impressed Sir Thomas Browne (1605–1682), whom we previously met in Parts 13 and 14 (Egerton 2004*a*, *b*; see also Robbins 2004). In his *Pseudodoxia Epidemica* (1646) he attempted to refute the "vulgar opinion" that "the earth was slenderly peopled before the floud" (Brown 1964: Book 6, Chapter 6). His postulations were not identical with Petau's, but he nevertheless followed Petau's methodology, and it is unclear exactly what his final figure represents (Egerton 1967:47). Nevertheless, he brought together human and animal demography and drew new conclusions. His preoccupation with the longevity of the patriarchs led him to introduce age as a factor in the balance of nature (Egerton 1966), and age was also one of the two factors controlling the size of populations, the other being numbers of offspring (Browne 1964:II, 428):

> *... there are two maine causes of numerosity in any kind or species, that is, a frequent and multiparous way of breeding, whereby they fill the world with others, though they exist not long themselves; or a long duration and subsistence, whereby they doe not only replinish the world with a new annumeration of others, but also maintaine the former account in themselves. From the first cause we may observe examples in creatures oviparous, as birds and fishes; in vermiparous, as Flies, Locusts, and Gnats; in animals also viviparous, as Swine and Conies; of the first there is the great example in the heard of Swine in Galilee, although it were an uncleane beast, and forbidden unto the Jews. Of the other a very remarkable one in Atheneus, in [his account of] the Isle Astipalea, one of the Cyclades now called Spampalia, wherein from two [conies] that were imported, the number so encreased, that the Inhabitants were constrained to have recourse unto the Oracle of Delphos, for an invention to destroy them.*
>
> *Others there are which make good the paucity of their breed with the length and duration of their days, whereof there want not examples in animals uniparous: First in bisulous or cloven hooft, as Camels, and Beeves, whereof there is above a million annually slain in England . . . .*

In this passage Brown introduced into the English language the terms multiparous, uniparous, oviparous, vermiparous, and viviparous. He emphasized that a

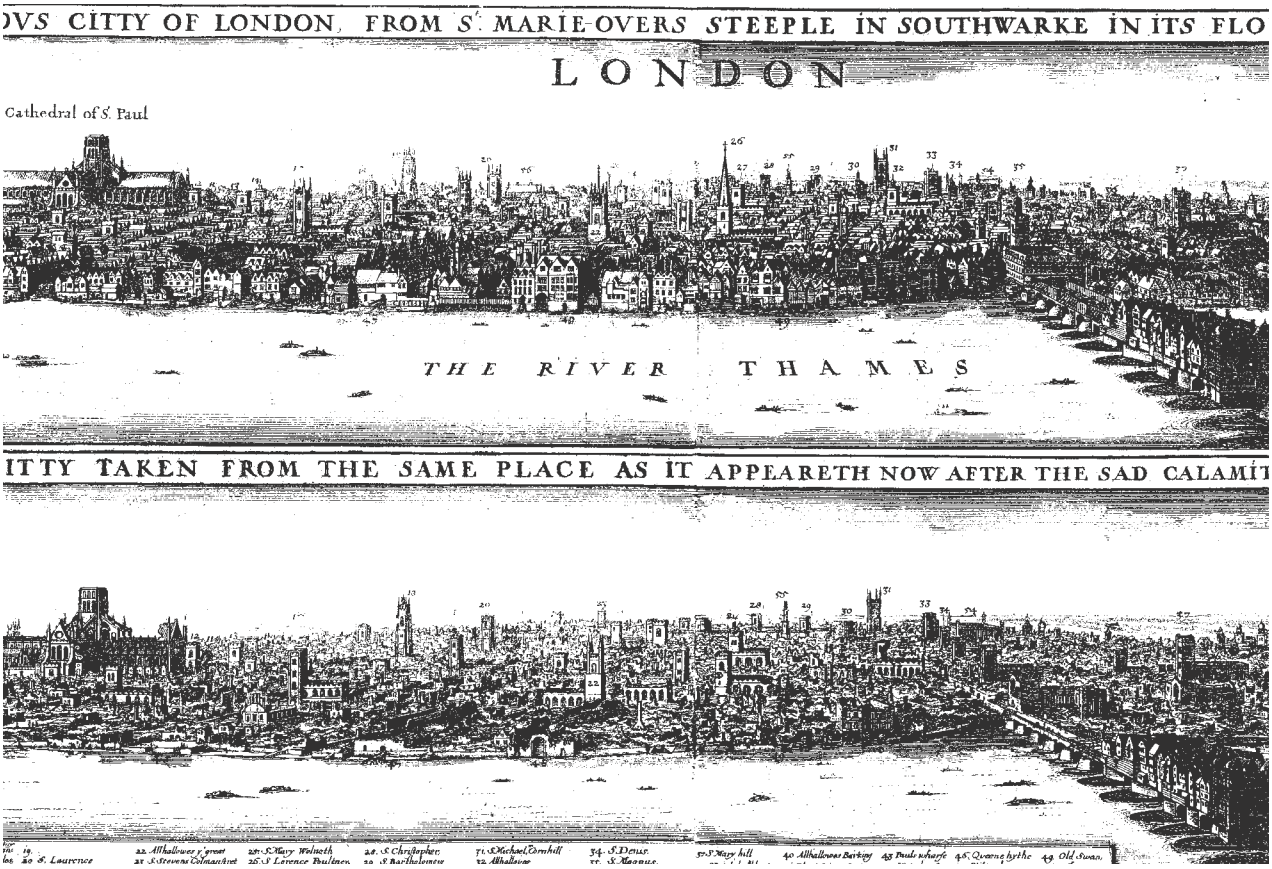

Fig. 1. Part of a panorama of London before and after the Great Fire of 1666. Wenceslaus Hollar. A catastrophe of this magnitude was not part of the statistical regularity Graunt found for London.

slow rate of reproduction did not deter increase in population when individuals of a species are long lived, with a long period of fertility. He compared in this respect the two digitated animals that are uniparous, humans and elephants. The latter carries the embryo for two years, but it also lives 100 years (according to Aristotle). Browne accepted both the balance of nature (long-lived species have few offspring; short-lived species have many) and the possibility of animal plagues, but he did not pursue the question of when the balance breaks down and there is such a plague. If asked, he might have mentioned that the conies lacked predators on Isle Astipalea.

Speculations about populating the world, whether by animals or humans, were not enough to found a new discipline of study. In 1662 a successful London haberdasher, John Graunt (1620–1674), who also held several city offices, published *Natural and Political Observations Mentioned in a following Index, and Made upon the Bills of Mortality: with Reference to the Government, Religion, Trade, Growth, Ayre, Diseases, and the several Changes of the said City.* This first statistical treatise, which went through five editions by 1676 (fifth edition reprinted in Hull 1899:II, 314–435) demonstrated the usefulness of demographic statistics for government, medicine, and other purposes, and he aroused the interest of scholars and government officials throughout Europe (Glass 1964, Egerton 1972, Lewin 2004). London published weekly its number of deaths and their probable causes (a sample of these bills of mortality are reproduced in Wolf 1950: 589–593). Graunt stated in his preface that he felt the bills of mortality should have a greater use than merely warning people when the plague was increasing, or satisfying idle curiosity. Besides the stimulus of Graunt's civic spirit, it seems likely that his book was encouraged and guided by his friend, Sir William Petty (1623–1687), one of the original members of the Royal Society of London (Greenwood 1948:36–39, Egerton 1974, Barnard 2004). He explained that the London data had several defects that affected their accuracy: the frequency and geographical area covered in the reports vary through the years; there was a lack of standardized terminology to describe causes

of death; and christening records only indicated numbers of births within the state religion. Yet these data could still be used to make important discoveries. One of his most important discoveries was the regularity of phenomena when there is extensive data. The numbers dying from most causes—excluding epidemic diseases, but including chronic diseases, suicides, murders, and various accidents—remained about the same from year to year. The records indicated that a few more boys were born than girls, and that the sex ratio remained about equal. He tried to deduce from the data the size of the population, distribution of ages within the population, and the differences in mortality between city and country. Although his book was eye-opening, his procedures were sometimes difficult to understand, and his degree of accuracy was not easily assessed. He calculated the population of London as follows (Graunt 1662: Chapter 11):

> *...the number of* Child-bearing women *might be about double to the* Births*: forasmuch as such women, and with another, have scarce more than one Childe in two years. The number of* Births *I found, by those years, wherein the* Registries *were well kept, to have been somewhat less than the* Burials*. The* Burials *in these late years at a Medium are about 13000, and consequently the* Christenings *not above 12000. I therefore esteemed the number of* Teeming women *to be 24000: then I imagined, that there might be twice as many Families, as of such women; for that there might be twice as many women* Aged *between 16 and 76, as between 16 and 40, or between 20 and 44; and that there were about eight Persons in a Family, one with another, viz. The Man, and his Wife, three Children, and three Servants, or Lodgers: now 8 times 48000 makes 384000.*

This procedure might not inspire confidence in a modern statistician, but it was adequate at the birth of statistics. Furthermore, Graunt also attempted to estimate the population by three other methods. In addition to the weekly London bills of mortality, Graunt used christening records and statistics from the country parish of Romsey, which he compared to London statistics. When he compared the birth, marriage, and death statistics of London and Romsey, he learned that one in 50 die per year in Romsey, but in London it is one in 32. He concluded that life expectancy was greater in the country than in the city, and that the smoke of London was the factor causing shorter life spans.

Graunt may have calculated the population of England and Wales before he calculated the population of London, since the former calculation is in Chapter 7 and the latter in Chapter 11. In Chapter 7, he used the figure of 460,000 for the population of London, and by a very circuitous route he calculated the population of England and Wales as 6,440,000, which was more than a million too high (McEvedy and Jones 1978:43). If he had used his 384,000 figure for the size of London he would have come closer.

A modern ecologist listed the factors essential for adequate study of population as: "a biological unit at the level of ecological integration where it is meaningful to speak of a birth rate, a death rate, a sex ratio, and an age structure in describing the properties of the unit" (Cole 1957). This statement might have been a summary of Graunt's endeavor, because he made very good attempts to establish figures for each of these factors and to show their relationships in the biological unit of London. Because of the importance of his book, Graunt was voted a member of the Royal Society of London, and at the meeting of 19 August 1663 he contributed two brief notes on fish populations (Birch 1756–1757:Volume I, 294):

> *A pond new digged at Deptford for horses and other cattle to water in the year 1658, two male and two female carps being then put in, with intention to breed; in the year 1662 the pond being tainted with fish, so that the cattle refused to drink, there were then taken out of this pond eight hundred seventy and odd carps, of about nine inches in length, some more, some less; a great number of smaller fish being left for breeders.*
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> *And in the Severne* [River] *and elsewhere it hath been experimented, by fastening of small pieces of tape or silk through the gills of young salmon, that in two years they have advanced to near three foot in length.*

Brief though these reports are, Graunt pointed out two simple but useful methods to study fish populations.

It seems likely that Graunt's rather brief extrapolation from his calculations on London to calculations on the world (Graunt 1662:Chapter 11): "Adam *and* Eve*, doubling themselves every 64 years of the 5610 years, which is the* age *of the World according to the* Scriptures*, shall produce far more People, then are*

now in it. Wherefore the World is not above what the Scripture *makes it*"— may have inspired a synthesis of human and animal demography by an unlikely source, Sir Matthew Hale (1609–1676), Lord Chief Justice of England (Burnett 1682, Cromartie 1995, 2004). His *History and Analysis of the Common Law of England* was highly regarded and went through six editions by 1820, but Hale also had both a deep interest in religion and an amateur's interest in science, and those interests coalesced in *The Primitive Origination of Mankind, Considered and Examined According to the Light of Nature* (1677). He wanted to bolster the historical validity of the Book of Genesis with demographic evidence. After spending a lifetime in the law, he placed a high value on having as much evidence as possible to prove a point, especially when all the evidence was circumstantial. Consequently, he wrote a full synthesis of demography.

Fig. 2. Sir Matthew Hale. Burnett 1682.

Hale wanted to prove that the rate of human population growth since the Flood of Noah, supposedly about 5000 years ago, would yield the estimated contemporary world population. Graunt's research had been too restricted to actually prove his assertion to this effect. Hale attempted to answer four questions: (1) whether mankind would gradually increase if there were no environmental checks; (2) what environmental checks existed; (3) whether these checks have prevented an increase in human numbers during historical times; and (4) whether humanity had an origin in the not-too-distant past (Hale 1677:203–204). No one doubted a positive answer to his first question, but no one before Graunt had statistical data with which to reason. Hale used figures which he thought were more conservative than were likely true. He assumed that: a couple would be fertile for 20 years, they would live 60 years, the sex ratio of their children would be approximately equal, they would have six children but only two would reach maturity, these two would marry and produce two children of their own before their own parents died. When each generation died at age 60, there had been a net increase of four. This seemed to be a simple calculation, yet it was wrong; when the average couple produces only two maturing offspring, the population usually remains stable rather than increasing. (Hale's personal experience was as follows: he had 10 children, four of whom died in childhood; although the other six married, only two survived him; he had 18 grandchildren.) Hale then introduced figures from Aristotle concerning the age of reproduction, numbers of offspring, and longevity of commonly known animals.

Environmental checks to the increase of population had been known since antiquity. Dicaearchos, "a learned and eloquent peripatetic," wrote a book, since lost, on the causes of such checks, and Cicero (106–43 BC) summarized Dicaearchos' findings (1949: Book 2, Chapter 5, p. 78):

> *First having reckoned up all other causes of it, such as inundations, pestilences, and famines, and even sudden incursions of furious wild beasts, by which he assures us some whole nations have been devoured; and then placing on the other side, wars, seditions, and such like misfortunes, which men were the occasion of; he endeavours to show … that a great many more have been destroyed by these than by all other accidents or calamities whatsoever.*

Graunt was first to give enough statistical data to provide a basis for assessment of checks on population, but since his data was for a single city over a short time period, Hale evaluated other accounts of plagues, famines, wars, internecine conflicts, floods,

and conflagrations. He wanted to show that, taken together, they did not prevent population growth, thereby discrediting the ancient Greek notion that there were cycles of calamities which appear periodically and leave only a few people and animals to repopulate the world (Hale 1677:217–225). His main evidence was an impressive analysis of historical records by which he showed that the populations of both Jews and English had increased throughout their recorded history despite epidemics, famines, floods, wars, and other calamities (Hale 1677:230–238).

Moving on to animals, he pointed out that people control the population of livestock by eating them (though not true of horses) and control cats and dogs by destroying unwanted young, as men also do to noxious wolves and foxes. The same cause applied to domestic fowl and noxious birds, while other birds die from winter cold or lack of food. The kinds of animals that produce many offspring also have short lives. Fish inspired Hale to deeper thought because "*their Increase seems to be much greater than of Men or Brutes ...*" (Hale 1677:208). Drawing upon Aristotle's *History of Animals* (Book 6, Chapter 13), Thomas Browne, and other English sources, he discussed six limiting factors: (1) eggs not fertilized by males are unfruitful, and other fish also eat fish eggs, (2) people eat many fish, (3) as do predatory fish, and (4) birds of prey, (5) extreme frost kills pond fish by either freezing them or "*by the exclusion of the ambient Air*" and great heats and droughts also kill fish in lakes, ponds, and rivers. Hale had some skepticism about spontaneous generation, but he was unwilling to reject it completely for smaller creatures. He accepted the balance of nature as a fact and then argued that the same was not true for people (Hale 1677:209–211).

Another question Hale faced was how to account for the populations of humans and animals in America. He accepted the suggestion made by the Spanish Jesuit José de Acosta (1540–1600), who was a missionary in Peru during 1571–1584 and in Mexico during 1585–1586, before becoming rector at the Jesuit college in Salamanca, Spain and publishing *Historia natural y moral de las Indias* in 1590 (Beddall 2000). Acosta acknowledged that Indians might have come to America by boat, but the only plausible way he could explain how large animals reached America after the Flood of Noah was by a land bridge between Asia and America, and he suspected that people came over it also (De Acosta 1880, Book 1, Chapters 16–21, Jarcho 1959, Petit and Théodoridès 1962:219–222, Browne 1983:12,). Sir Walter Raleigh (1552?–1618) had thought that Noah's Ark could not have accommodated representatives of all animals, but that this was unnecessary since some are of "*mix'd natures*" and could be "*generated again by others, as the mules, the hyenas, and the like: the one begotten by asses and mares, the other by foxes and wolves ...*" and still others are changed by transplantation to a different climate (Raleigh 1733:Book 1, Chapter 7, p.57). Hale accepted the speculations of both Acosta and Raleigh and believed there were four ways transmutations might occur: hybridization, mutation, cultivation, and changes in soils and climates (Hale 1677:199–200).

Hale's *Primitive Origination of Mankind* was praised by Graunt's friend, Sir William Petty and mentioned by other English authors; it was also translated into German, and remained on a book list for British theology students until 1792 (Egerton 1967:81–84). However, none of that attention led to further studies, except by Petty. Petty, after Graunt's death, undertook studies similar to Graunt's, which Petty called "political arithmetic." He calculated the population of London as 670,000 in 1682, and that its population had doubled in 40 years (Hull 1899:II, 460). He calculated the population of England and Wales in 1682 as 7,400,000, which was less accurate than Graunt's estimate in 1662. Petty also projected the growth of population in London and in England and Wales from 1565 to 1842, and he speculated on the growth of the world's population (Hull 1899:II, 463–472).

A philosopher of science commented that science arises from myth (Popper 962:3–59), and we have seen that demography arose in the 1600s inspired by the Genesis myth of Noah and his ark. However, it was elaborated by real statistical data from England and made good strides toward a new discipline. Yet despite the original work done by Graunt and Petty and the interesting synthesis written by Hale—all of which was much more substantial than anything written in antiquity on these subjects—their publications did not establish a continuous tradition of investigation. Their books were appreciated because these authors had apparently done what needed to be done, and there was no scientific context which impelled others to pursue these subjects further. For anyone to do more, there needed to be available more data on cities and/or animal populations. The collection of such data would have required more foresight than was usual in governments of the time, and the utility of such data was not apparent to governments.

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