Development of the indigeonus intestinal flora of infants in health and disease

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There have been no longitudinal studies of the flora in children under natural conditions and on its significance for health. This is important in preindustrial countries where infants are commonly breast-fed for prolonged periods and are exposed to an unsanitary environment.

The data to be presented were obtained in children from the Mayan village of Santa Maria Cauque (Mata *et al.*, 1967), without removing them from their environment and with minimum disturbance of the ecosystem. The bacterial colonization of the intestinal tract in the first week of life was studied in 50 children. Observations on the development of the flora were made in 12 of these who were followed throughout their first year of life.

The fecal flora was studied by techniques previously described (Mata *et al.*, 1969). Anaerobiosis was obtained in special chambers (Schaedler *et al.*, 1965) or was produced and monitored with Gaspaks (Brewer and Allgeier, 1966).

RESULTS

Children were born with an average weight of one pound less than European children (Mata *et al.*, 1967). All children in the cohort were breast-fed for several months. Weaning began at the age of three months or later by periodic administration of small amounts of fluids, and of gruels and solids by six months. Food supplements were scarce and of poor nutritive value. The growth of children departed from expected standards at an early age, resulting in a deficit often observable in the first year.

Bacteria were found in more than half of the specimens collected within 11 hours of birth. Bacteria were present in all samples collected from 12 to 23 hours following birth, in concentrations occasionally reaching 10^{11} per gram. In the first day of life, aerobic bacteria were often more abundant than anaerobic bacteria. Bifidobacteria were not found during this period, and began to appear on the second day. At the end of the first week, however, they predominated, with concentrations of 10^{11} per gram. Streptococci were next in frequency and also numerous, although less than the bifidobacteria. After the stabilization of the flora, occurring at the end of the first week of life, the flora evolved in a subtle manner, with a progressive acquisition of certain bacteria as a function of time, and a change in the relative concentration of the main bacterial groups. In periods of good health, bifidobacteria were found in nearly 100% of cultures throughout the first year of life. Streptococci were present in less than half of the cultures made in the first four months of life, in a concentration of 10^8 per gram or more. The frequency of isolation increased with age and by six months they were found in three fourths of the cul-

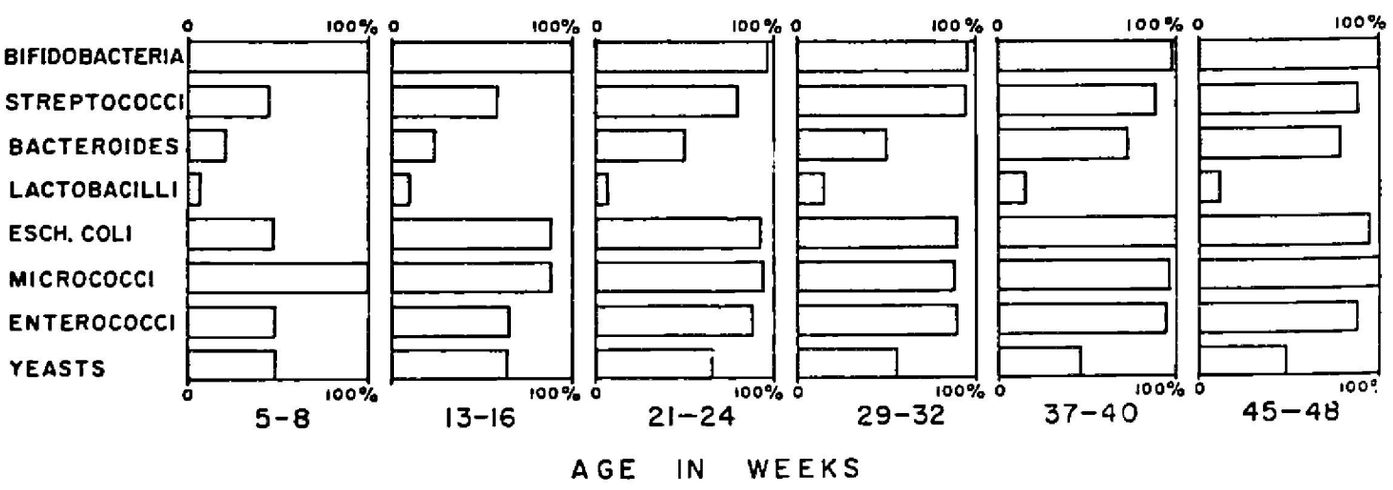

Fig. 1. Occurrence of certain bacterial groups in feces of 12 children followed throughout the first year of life, Santa Maria Cauque, Guatemala. The number of cultures studied in each age group varied from 13 to 31, and corresponded only to periods of good health.

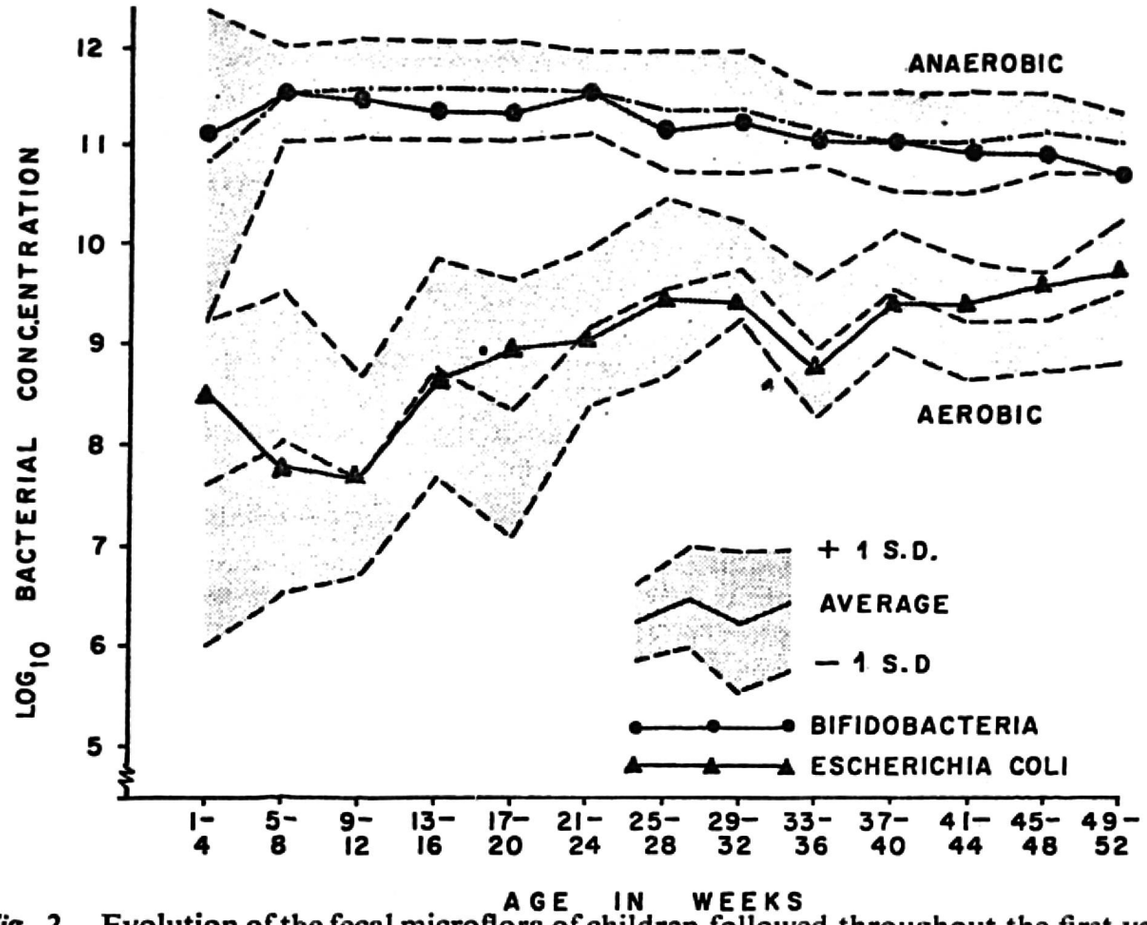

Fig. 2. Evolution of the fecal microflora of children followed throughout the first year of life, Santa Maria Cauque, Guatemala. The number of cultures studied varied from 53 (1–4 weeks) to 13 (45–48 weeks), and corresponded only to periods of good health.

tures, and in more than 90% by the end of the first year of life (Fig. 1). Bacteroides were present in only 25% of cultures during the first four months of life, increasing to 50% by six months, and to 75% by one year.

The evolution of the anaerobic flora is shown in Figure 2. Only cultures yielding 10^8 bacteria per gram of wet feces or more, corresponding to disease-free periods, were used. Bifidobacteria were 3 logs more abundant than the aerobes in the first two months of life; later, the difference was only of 1 or 2 logs. Anaerobes were found consistently in high and steady numbers throughout the first year. The aerobic component showed a progressive change toward higher numbers, particularly during the periods 9–12 and 17–24 weeks of life. This component was formed almost exclusively by enterobacteriaceae, of which *Escherichia coli* predominated (Fig. 2).

There were no marked differences in the total counts of anaerobic and facultative bacteria in diarrhea specimens when compared with samples collected during periods of health, except for a slight decrease in anaerobes observed one day after onset of diarrhea. To explore if this was contributed by special cases, only the severe diarrheas were tabulated. Marked differences were then observed, consisting in a decrease in the number of anaerobes and an increase in the facultative Gram-negative bacilli, occasionally to counts of 10^{11} per gram.

No differences in the kinds and relative proportions of the flora were detected in the feces during respiratory diseases, measles, varicella, pertussis, and others.

Differences in the fecal flora were observed in hospitalized malnourished children (Dale and Mata, 1968). These consisted in a higher prevalence of *Shigella* than usually found in the region, and in lower concentrations of anaerobic bacteria and coliforms. In children who had recovered from kwashiorkor, significant bacterial overgrowth was found in the jejunum of several of them.

REFERENCES

Brewer, J. H. and Allgeier, D. L. (1966): Safe self-contained carbon dioxide-hydrogen anaerobic system. *Appl. Microbiol., 14*, 985.

Dale, D. C. and Mata, L. J. (1968): Studies of diarrheal disease in Central America. XI. Intestinal bacterial flora in malnourished children with shigellosis. *Amer. J. trop. Med. Hyg., 17*, 397.

Mata, L. J., Carrillo, C. and Villatoro, E. (1969): Fecal microflora in healthy persons of a preindustrial region. *Appl. Microbiol., 17*, 596.

Mata, L. J., Urrutia, J. J. and Garcia, B. (1967): Effect of infection and diet on child growth: experience in a Guatemalan village. In: *Nutrition and Infection*, pp. 112–126. Editors: G. E. W. Wolstenholme and M. O'Connor. Ciba Foundation Study Group No. 31, J. and A. Churchill Ltd., London.

Schaedler, R. W., Dubos, R. and Costello, R. (1965): The development of the bacterial flora in the gastrointestinal tract of mice. *J. exp. Med., 122*, 59.