The Widespread Occurrence of Enteric Flagellar Phages

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The first phage known to adsorb to bacterial flagella was isolated by Sertic & Boulgakov (1936a), who found it attacked motile but not non-motile strains of various enterobacteria. Since then, such phages have only been reported in 1941, when three isolates were obtained from the East River, New York, by Rakieten & Bornstein (1941). Flagellar phages nevertheless appear to be very common in sewage, for we have found them in 5 of 18 samples examined for I phages (Lawn et al. 1967). All the new phages are closely related to the original flagellar phage named \( \chi \) (Sertic & Boulgakov, 1936b), which we therefore propose to name \( \chi_1 \), the new phages being \( \chi_2 \) to 6 as the phages isolated by Rakieten & Bornstein (1941) are no longer available (M. L. Rakieten, personal communication).

The method of selection consisted of incubating 1 ml. of sewage, clarified by centrifugation for 15 min. at 700 g, with 9 ml. Oxoid Nutrient Broth no. 2 and 1 ml. of an unshaken overnight culture of \( \text{Salmonella typhimurium} \ M385 \) for 18 hr at 37°. The culture was then chloroformed or centrifuged, and the supernatant titrated by plating drops of 0.02 ml. on an overlay of 0.35% nutrient agar inoculated with \( \text{Escherichia coli K12} \). The flagellar phages formed indistinct plaques about 0.5 mm. in diameter and were identified initially by examining material from the plaques by electron microscopy (Bradley, 1965). The host range of phage \( \chi_1 \) is determined primarily by the antigenic structure of the bacterial flagella, not by that of the bacterial body (Meynell, 1961), and \( \chi_1 \) is known to adsorb to the flagella of both \( \text{S. typhimurium} \) and \( \text{E. coli K12} \) (Meynell, 1961). These species possess different somatic antigens and so, although both somatic and flagellar phages may replicate on \( \text{S. typhimurium} \) during enrichment, none of those which adsorb to the bacterial body will infect \( \text{E. coli} \), thus selecting phages which adsorb to its flagella. The source of the new \( \chi \) phages was: \( \chi_2 \), Croydon, Surrey; \( \chi_3 \), Billericay, Essex; \( \chi_4 \), Halstock, Devon; \( \chi_5 \), Dundee, Angus; \( \chi_6 \), Pavia, Italy. Phage \( \chi_6 \) was isolated only recently and has not been studied in detail.

Phages \( \chi_2 \) to 5 closely resembled phage \( \chi_1 \). The individual particles had heads which were hexagonal in outline and measured about 660 Å between their parallel surfaces; the tail was about 2500 Å long and had a tapering end; and the tail fibre (Schlade, Adler & Ris, 1967) was usually seen as a tangled mass at the tip of the tail. The plaques were indistinct and about 0.5 mm. in diameter, even when very soft overlays were used. The host ranges of phages \( \chi_2 \) to 5 were identical when tested against a representative set of salmonella strains: none plated on non-motile strains or on motile strains forming g-related antigens like gm or gst (Meynell, 1961). Antisera prepared against phages \( \chi_1 \), 2 and 3 had \( k \) values of about \( 3 \times 10^8 \) when tested against the homologous phages. The sera also neutralized the heterologous phages, although the \( k \) values were generally about tenfold less.

The recently isolated \( \chi \) phages are therefore closely related to that isolated in France 31 years ago, and, judging from the frequency with which they have been
isolated from sewage obtained from different regions, they are presumably widely distributed.

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REFERENCES


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