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TYPING OF PARATYPHOID B BACILLI BY MEANS OF Vi BACTERIOPHAGE*

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An account was given in a previous paper (Felix, 1943) of experience with the bacteriophage typing of typhoid bacilli according to the technique of Craigie and Yen (1938a, 1938b). The conclusion reached was that the method is an indispensable laboratory aid to the control of typhoid fever. In this country during the past few years paratyphoid B fever has been much more prevalent than typhoid fever. It appeared, therefore, highly desirable to investigate the possibility of applying Vi-bacteriophage action to the examination of paratyphoid B cases and carriers.

The presence in cultures of *Bact. paratyphosum* B of an antigen resembling the typhoid Vi antigen was described some years ago (Felix and Pitt, 1936), but most workers paid little attention to this finding. Kauffmann (1936a, 1936b) attempted to identify the antigen with one of the several components of the complex O antigen assigned to the paratyphoid B bacillus in the Salmonella scheme of Kauffmann and White (Salmonella Subcommittee, 1934). The intricacies of this controversial problem cannot be discussed here, but it may be stated that unpublished experiments carried out by one of us (A. F.) in collaboration with Miss R. M. Pitt before the war strongly indicated that paratyphoid B bacilli possess a heat-labile somatic antigen that is essentially similar to the typhoid Vi antigen, though differing from it in certain respects. Moreover, experience during the present war confirms the earlier observation, and every paratyphoid B strain isolated in this country which has been examined up to the present time contains the heat-labile "Vi" antigen.

These facts are the theoretical basis of the present investigation. The data from the bacteriological and serological experiments will be published elsewhere; only those results are summarized here which help to make clear the practical application of the method.

Isolation of Anti-Vi and Anti-O Bacteriophages

During 1941 large outbreaks of paratyphoid B fever occurred in different parts of the country, and, thanks to the co-operation of many pathologists, nearly 500 cultures of the paratyphoid B bacillus were collected and examined within a few months. Bacteriophages were grown from specimens of faeces of paratyphoid B patients, convalescents, and carriers; from freshly isolated "smooth" cultures that were found to be phage-contaminated; and from "rough" variants of paratyphoid B strains; a few bacteriophages were also received from Dr. R. Knox of the E.P.H. Laboratory, Leicester. It was soon found that most of the phages obtained from these sources were anti-O phages that acted on paratyphoid B bacilli as well as on *Bact. typhi-murium* bacilli and many other members of the Salmonella group. Even minor O-antigenic components that are common to the various Salmonella species, though they are not listed in the Kauffmann-White diagnostic scheme, provide an adequate point of attack for anti-O bacteriophages.

On the other hand, a number of phages were found which were specific for the paratyphoid B bacillus. These phages

did not attack any of the other Salmonella species tested, and were therefore considered to be specific anti-Vi paratyphoid B phages. They differed, however, in one respect from the corresponding typhoid Vi phages described by Sertic and Boulgakov (1936), Scholtens (1936), and Craigie and Brandon (1936). The typhoid Vi phages, when employed in the form of concentrated unadapted preparations, attack every strain, or almost every strain, of the typhoid bacillus, so long as the bacilli contain enough of the Vi antigen to provide the required point of attack. Our Vi paratyphoid B phages, however, acted selectively on certain paratyphoid B strains but failed to lyse other strains, in spite of the fact that these also contained the heat-labile somatic Vi antigen.

It is noteworthy that the non-specific O phages were grown readily from specimens of faeces, whereas the specific Vi phages could be isolated only exceptionally from this source. Thus, of the first ten anti-O phages examined seven were derived directly from faecal specimens and three were isolated during the process of purification of Vi phages; which was in each instance carried out by repeated transplantation from single plaques. On the other hand, the first ten anti-Vi phages were obtained from the following sources: five from lysogenic "rough" variants, four from phage-contaminated "smooth" cultures of the paratyphoid B bacillus, and only one direct from a specimen of faeces.

Although the Vi bacteriophages had been isolated from patients in localities as widely separated as Aberdeen and Inverness in the north, and Bristol and Exeter in the south, no difference in their affinities for different paratyphoid B strains could be detected. Every strain examined was either lysed by all the Vi phages or was resistant to all of them, no matter in which part of the country the strain had been isolated. All the strains examined during any given outbreak usually behaved in a precisely similar manner towards all the available Vi phages; this was interpreted as indicating that the cases had a common source of infection. Such confirmation by laboratory findings, though of limited value, was appreciated by the medical officers of health who were investigating the outbreaks (Davies, Cooper, and Fleming, 1942; Parry, 1942). There seemed, however, at that time to be little hope of attaining our goal—namely, the differentiation of paratyphoid B strains into a number of distinct Vi-phage types. As was proved later, nearly all the larger outbreaks during 1941 were due to strains belonging to the same bacteriophage type—namely, Type 1 (see Table III).

Adaptation of Vi Bacteriophages

The position at once changed when the first instance of adaptation of a Vi phage had been observed. This occurred in the course of the examination of cultures from a relatively small outbreak of paratyphoid B fever in Ipswich during July-Aug., 1941. Thanks to the most helpful co-operation of Dr. P. H. Martin of the E.P.H. Laboratory, Ipswich, we were able to examine the strains from all the patients concerned and also from a number of cases that occurred at the same time elsewhere in East Suffolk. The "Suffolk" strains were all lysed by the available Vi phages in very high dilutions, exceeding in some instances even a dilution of 1 in 10 millions, whereas the "Ipswich" strains were all insusceptible. When,

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however, certain of the phage preparations were applied in a concentration about a million times stronger than the usual amount a few plaques were occasionally produced on some of the "Ipswich" strains. New preparations of bacteriophage grown from these plaques still lysed the "Suffolk" strains, but they also lysed the "Ipswich" strains to the same titre. Using one of the original Vi phages, which had been isolated from a patient in Aberdeen, and the new preparation derived from the "Aberdeen" phage and adapted to the "Ipswich" strains, we were now able to identify every strain that belonged to the "Ipswich" type.

The next Vi phage to be specifically adapted to certain strains was obtained by an analogous procedure during the examination of strains from a small outbreak in Southampton. The cultures had been isolated by Dr. J. T. Duncan of the E.P.H. Laboratory, Winchester, during May-June, 1940, and were found to be resistant to all the original Vi phages, including the "Aberdeen" phage and the adapted "Ipswich" phage. After numerous unsuccessful attempts a few plaques were eventually produced by the adapted "Ipswich" phage on some of the Southampton strains, and from these plaques another adapted phage was initiated. The new phage preparation possessed a strong lytic power for all the cultures from the Southampton outbreak, but had entirely lost the lytic power for the "Ipswich" strains which it had acquired during the previous process of adaptation. Its affinity for the parent strain ("Aberdeen" strain) still remained unchanged. The original "Aberdeen" Vi phage was now labelled "Type 1," and the adapted "Ipswich" and "Southampton" phages were designated as "Type 2" and "Type 3" respectively.

TABLE I.—Showing the Reactions of Type Strains of *Bact. paratyphosum* B and *Bact. typhi-murium* to Anti-Vi and Anti-O Bacteriophages

Type Strains		Antigens Present in the Strains	Anti-Vi Bacteriophages					Anti-O Bacteriophage
			Bact. paratyphosum B				Bact. typhimurium Type 1	
			Type 1	Type 2	Type 3a	Type 3b		
Bact. paratyphosum B	Type 1 ..	Vi + O	CL	CL	CL	+++	—	CL
	" 2 ..	Vi + O	—	CL	CL	—	—	CL
	" 3a	Vi + O	—	—	CL	SCL	—	CL
	" 3b	Vi + O	—	—	—	SCL	—	CL
	Untypable (Group Z)	Vi + O	—	—	—	—	—	CL
Bact. typhimurium	Type 1 ..	Vi + O	—	—	—	—	CL	CL
	Vi-negative variant	O	—	—	—	—	—	CL

CL=Confluent lysis with standard loopful of test dilution of phage.

SCL=Semi-confluent lysis with standard loopful of test dilution of phage.

+++ = Numerous discrete plaques, subnormal in size.

So far only four different Vi-phage types of *Bact. paratyphosum* B have been identified; their relationship to each other is indicated in Table I. Type 1 strains are lysed by all the available BVi* phages, whereas the other three types are attacked only by the corresponding adapted BVi phages. Group Z is the provisional designation chosen for the untypable strains that are resistant to all the BVi phages so far available in spite of the fact that the cultures contain the BVi antigen. There can be little doubt that this group comprises a number of further Vi-phage types that have not been identified because the corresponding type phages have not yet been isolated.

If the typing scheme outlined in Table I is compared with that which was first devised by Craigie and Yen (1938a) for the typing of the typhoid bacillus it is seen that the two are very similar, and indeed almost identical. The first place in each of the two schemes has been assigned to the type of bacillus that is sensitive to all the adapted phage preparations; the phages corresponding to these types—namely, Type A phage of the typhoid bacillus and Type 1 phage of the paratyphoid B bacillus—nevertheless possess a high degree of specificity. The remaining types in the two schemes are all characterized by their particular sensitiveness to the homologous adapted type phage. The relationship between subtypes of the paratyphoid B bacillus (Types 3a and 3b) is also similar to that obtaining between the various subtypes of the typhoid bacillus.

* The symbol BVi is used throughout this paper to denote the Vi antigen of the paratyphoid B bacillus.

Bacteriophages adapted to Types 2, 3a, and 3b were isolated many times later in the course of this investigation. These phage preparations were obtained as the result of cross-reactions between cultures and Vi phages that had been derived from outbreaks or sporadic cases in various parts of the country. Whichever of these phage preparations were employed in the typing of paratyphoid B strains, the results obtained were invariably the same—namely, identical with those summarized in Table I.

The table also shows that *Bact. typhi-murium*, which shares the heat-labile Vi antigen with *Bact. paratyphosum* B (Felix and Pitt, 1936), is not lysed by any of the four BVi-type phages. *Bact. typhi-murium* is sensitive to its own specific Vi phages, of which two different types have been identified so far. Table I shows only one of these. It remains to be investigated whether the specificity of these phages is as strict as it appears to be at the present time.

The procedures that led to the adaptation of anti-Vi phages were also applied to the examination of a number of anti-O phages. In no instance, however, did we succeed in training an anti-O phage to develop strain specificity. This finding is of great interest, from the theoretical point of view, since it provides additional evidence of the similarity between the Vi antigen of typhoid and that of paratyphoid B bacilli. Table I shows that an anti-O phage attacks strains belonging to all known Vi-phage types of the paratyphoid B bacillus and also Vi-positive and Vi-negative strains of *Bact. typhi-murium*.

The Epidemiological Significance of Paratyphoid-B Vi-phage Types

It has already been mentioned that the subdivision of paratyphoid B strains into Vi-phage types first proved its usefulness during a small outbreak in Ipswich, July-Aug., 1941, which was examined bacteriologically by Dr. P. H. Martin. The epidemiology of this outbreak has been very thoroughly investigated by the Ministry of Health, in co-operation with the E.P.H.L. Service, and a report by Dr. J. R. Hutchinson appears on page 130 of the present issue (Hutchinson, 1943). The clear-cut result of the field inquiry was that all the cases from which Type 2 bacilli had been isolated had a common source of infection, whereas the cases that were due to Type 1 bacilli were unrelated to that source.

Many outbreaks, large and small, have been investigated since, and our experience so far has been that the epidemiological significance of paratyphoid-B Vi-phage types is much the same as that of the now well-established typhoid Vi types. A few instances may be mentioned here by way of illustration. During the paratyphoid B outbreak in Liverpool, May-Sept., 1941 (Holt, Vaughan, and Wright, 1942), 72 cultures, derived from 66 patients or temporary excretors, were examined. These included cultures isolated from three employees of the bakery responsible for the outbreak and from a synthetic cream used by the firm in question. All these cultures were found to belong to Type 1. In an outbreak in Bristol, July-Oct., 1941 (Davies, Cooper, and Fleming, 1942), five strains from the primary wave in August and six strains from the secondary wave in September were typed, and it was found that again all the cultures were of Type 1. On the other hand, thirteen strains from the outbreak in Consett, June, 1940 (Warren, 1941), and six strains from the 1939 outbreak in Bebington (Hughes and Harwood, 1940) were typed, and all were found to belong to Type 3a.

Several chronic faecal carriers of *Bact. paratyphosum* B have been examined repeatedly over periods varying from a year to over three years. The phage type of the excreted organism in every instance remained unchanged during the period of observation. These results permit us to state with confidence that the typing of paratyphoid B bacilli by the Vi-phage technique is a reliable aid to the epidemiological investigation of cases or outbreaks of the disease.

Paratyphoid-B Vi-phage Types Prevalent in England, Wales, and Scotland during 1940-2

The results so far obtained with the typing of strains of the paratyphoid B bacillus have been summarized in Tables II and III. The number of cultures examined in the course of this investigation was 808, including about 100 cultures from the late W. M. Scott's collection; the number of patients and

carriers, temporary or chronic, from whom the cultures had been derived was 714. Many paratyphoid B outbreaks of considerable size occurred in the British Isles during 1941, and nearly all of these were due to Type 1 bacilli. As a sequence to these outbreaks, cultures of Type 1 strains from convalescent patients and temporary excretors continued to be sent in for examination throughout the following winter and well into the first quarter of 1942. It seemed advisable, therefore, to choose March 31, 1942, as the date separating the "epidemic" year 1941 from the "non-epidemic" period that followed it. The distribution of the various types during the three years under observation can thus be traced more accurately than by strictly adhering to yearly periods.

TABLE II.—Showing the Vi-phage Types of *Bact. paratyphosum* B found in England, Wales, and Scotland during April, 1940, to March, 1943

Part I						
Vi-phage Types of <i>Bact. paratyphosum</i> B	Number of Patients and Carriers from whom Paratyphoid B Strains belonging to the Various Vi-phage Types have been Isolated					
	April, 1940, to Dec., 1940		Jan., 1941, to March, 1942		April, 1942, to March, 1943	
	No.	%	No.	%	No.	%
Type 1	95	55.6	349	79.3	37	41.1
" 2	5	2.9	34	7.7	3	3.3
" 3a	51	29.8	33	7.5	38	42.2
" 3b	1	0.6	4	0.9	1	1.1
Untypable (Group Z)	19	11.1	20	4.6	11	12.2
Total	171		440		90	

Part II.—Notified Cases of Enteric Fevers in England and Wales

	1938	1939	1940	1941		1942
				Jan.-June	July-Dec.	
Typhoid fever ..	—	—	—	—	677	464
Paratyphoid fever ..	—	—	—	—	2,941	404
Total typhoid and paratyphoid fevers	1,322	1,479	2,833	1,145	3,618	868

In order to assess the significance of the figures shown in Part I of Table II it is necessary to emphasize that the method of collecting the cultures for typing has not been the same throughout the whole period under review. During the initial stages of the investigation it was felt that no useful information could be obtained from the examination of sporadic cases or small groups of cases, and these were neglected almost entirely. Most of the cultures collected during 1940 and 1941 were therefore obtained from cases belonging to larger outbreaks

of the disease. In March, 1942, when the number of available Vi-type phages had risen to three, it was decided to extend the investigation to include strains from sporadic cases or from small groups of cases. This change was a timely one, since the year 1942 proved to have the lowest number of notified cases of enteric fevers ever recorded in England and Wales. The total notifications, based on the weekly returns of the General Register Office, are shown for comparison in Table II.

The typing of a small fraction of the total number of cases, such as has only been possible up to the present time, obviously provides a very rough indication of the frequency-distribution of the different Vi-phage types. Carefully organized surveys, covering all parts of the country and carried out for a number of years, are required in order to obtain a reasonably adequate picture. It is, however, clear that the figures for 1940 and 1942 approximate more closely to the true frequency-distribution of the various types than the 1941 figures, which reflect the epidemic spread of Type 1 bacilli. The prevalence of this type during 1941 was obviously due to accidental causes, and not to any particular virulence of Type 1 bacilli.

It is of especial interest to note that the proportion of strains that could not be typed with the four type phages so far available has been very small. The highest figure was that for 1942—namely, 12% of the total number examined. In a similar series of cases of typhoid fever from this country (Felix, 1943) the proportion of untypable strains was slightly higher (69 out of 432 strains, or 15.9%). These figures are remarkable in view of the fact that the typhoid strains were tested against twenty-two different Vi-type phages, whereas only four phages were available for the typing of paratyphoid B bacilli. The significance of these observations is at present a matter for speculation. It is possible that by mere chance only a small number of the different Vi-phage types of paratyphoid B bacilli that are indigenous to this country were encountered during the present investigation. An alternative possibility is that the Vi antigen of *Bact. paratyphosum* B is not capable of variation to the same degree as the Vi antigen of *Bact. typhosum*—that is to say that the former has developed fewer Vi-phage types than the latter. Future investigations in this country and abroad will give the answer to these queries.

Paratyphoid B bacilli do not lose their specific Vi antigen as readily as do typhoid bacilli. In the corresponding series of strains of *Bact. typhosum* that had been typed by the bacteriophage technique (Felix, 1943) eight strains could not be typed because the cultures were Vi-negative "O" variants. In the present series of 714 strains of *Bact. paratyphosum* B

TABLE III.—List of Phage-typed Outbreaks of Paratyphoid B Fever in England, Wales, and Scotland

Outbreaks				Strains of <i>Bact. paratyphosum</i> B examined by the Vi-phage Method			Reference
Year	Months	Place	No. of Cases Notified	No. of Strains Typed	Vi-phage Type	Cultures received from	
1931	Feb., March	Epping and district	312	2	1	Metropolitan Water Board	Bullough (1931)
1936-7	Dec., Jan.	Liverpool and district	132	2	1	Prof. H. D. Wright	Frazer, Glover, and Glass (1937)
1939	Aug.-Oct.	Bebington	51	6	3a	Dr. H. H. Mole	Hughes and Harwood (1940)
1940	April	Southampton	10	6	3a	E.P.H. Laboratory, Winchester	—
	June	Consett and district	56	13	3a	E.P.H. Laboratory, Barnard Castle	Warren (1941)
	June-Sept.	Kettering and district	213	18	1	E.P.H. Laboratory, Leicester	Hogg and Knox (1941)
	July, Aug.	Exeter	60	29	1	Dr. W. A. Robb	Page (1940)
	May, June	Bristol	34	3	1	Dr. K. E. Cooper	Davies, Cooper, Wiseman, and Davies (1940)
	Aug.-Dec.	Sheffield	39	7	3a	Prof. Wilson Smith	—
1941	March	Inverness and district	200	5	1	Dr. H. J. R. Kirkpatrick	—
	May	Dundee	178	3	1	Prof. W. J. Tulloch	—
	June	Taunton	28	6	Group Z	D. R. Wood, F.I.C.	—
	May-Sept.	Liverpool and district	883	72	1	Prof. H. D. Wright	Holt, Vaughan, and Wright (1942)
	May-Oct.	Birmingham and district	254	63	1	Dr. H. Henry	—
	July-Oct.	Bristol	203	11	1	Dr. K. E. Cooper	Davies, Cooper, and Fleming (1942)
	July, Aug.	Ipswich	16	16	2	American Red Cross-Harvard Unit	Hutchinson (1943)
	Sept.	East Hampshire	33	11	1	E.P.H. Laboratory, Ipswich	—
	Oct., Nov. Dec.	St. Albans	21	11	1	E.P.H. Laboratory, Winchester	—
		Torquay	6	4	Group Z	Prof. L. P. Garrod	—
1942	Jan.	Ely	10	4	1	E.P.H. Laboratory, Cambridge	E.P.H.L.S. Monthly Bulletin, April, 1942
	April	Locking	15	6	3a	D. R. Wood, F.I.C., Taunton	—
1943	Jan.	Hastings	35	10	3a	Dr. P. Lazarus-Barlow	—

not a single strain remained untyped for that particular reason. All the cultures listed in Table II as untypable (Group Z) strains were examined in agglutination tests with pure O and pure Vi immune sera and were found to contain the heat-labile BVi antigen. On the other hand, paratyphoid B cultures that show the accepted criteria of "roughness" (Arkwright, 1930) cannot be typed. According to the degree of antigenic degradation which they have suffered, such cultures may or may not be lysed by anti-O phages; they are, however, invariably resistant to the action of anti-Vi phages.

Table III shows in chronological order those outbreaks of paratyphoid B fever in the British Isles that have been typed by the Vi-phage method. Many of these outbreaks have been described in detail in published reports, and the various epidemiological aspects raised by the authors have been reviewed in an interesting study by Savage (1942). No published accounts are available of those outbreaks mentioned in Table III to which no reference is printed in the table. The information concerning these outbreaks has been supplied by the pathologists from whom the cultures were received and by the General Register Office. The figures specified in Table II, when read in conjunction with the data recorded in Table III, will convey an indication of the distribution of the various types of paratyphoid B bacilli throughout the country. Table III shows that all the large outbreaks that occurred during 1941 were due to Type 1 bacilli.

This first survey of necessity furnishes only fragmentary information, but it shows clearly the scope of applicability of the new typing method. Its value as an epidemiological weapon is beyond doubt. The extent to which it can be usefully applied to the control of paratyphoid B fever depends solely upon the degree of co-operation between clinician, field investigator, and laboratory worker.

Summary

Anti-Vi bacteriophages that act specifically on *Bact. paratyphosum* B are described. Anti-O bacteriophages, on the other hand, attack strains belonging to many diverse *Salmonella* species.

Anti-Vi phages of *Bact. paratyphosum* B can be adapted to develop a high degree of specificity for particular strains, whereas anti-O phages are incapable of such adaptation.

Four separate and distinct Vi-phage types and subtypes of *Bact. paratyphosum* B have been identified so far, and a method of typing strains of paratyphoid B bacilli has been developed similar to that which was first devised by Craigie and Yen for the typing of typhoid bacilli.

Of 714 strains isolated from patients or carriers in Great Britain only 50 (7%) could not be typed by means of the available four Vi-type phages. The larger outbreaks of the disease in 1941 were found to have been caused by Type 1 strains.

The significance of paratyphoid-B Vi-phage types is the same as that of typhoid Vi-phage types. The typing of paratyphoid B strains isolated from sporadic cases or outbreaks is a valuable epidemiological weapon and is certain to be widely applied in the future.

We should like to express our thanks to the pathologists of the Emergency Public Health Laboratory Service and of many other public health or clinical laboratories for their co-operation throughout this investigation; to Dr. J. R. Hutchinson, Dr. W. H. Bradley, and Colonel C. Maddock of the Ministry of Health for help in collecting epidemiological data; and to Dr. C. M. Wenyon for hospitality at the Wellcome Research Institution.

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A NOTE ON THE VALUE OF PHAGE TYPING IN THE INVESTIGATION OF AN OUTBREAK OF PARATYPHOID B FEVER

BY

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Felix (1943) recently related his experiences of the typing of typhoid bacilli by means of Vi bacteriophage (Craigie and Yen, 1938), and in a companion article Bradley (1943) gave an account of the first application of this new knowledge to field investigations in this country, and proved, in peculiarly difficult circumstances, its value to epidemiologists. As a natural corollary Felix and Callow proceeded to apply a like laboratory technique to *Bact. paratyphosum* B—the preliminary results of which are reported on page 127 of this issue—and an opportunity recently occurred of ascertaining whether the harmony between the laboratory and field findings demonstrated in typhoid also held in paratyphoid B fever.

In Ipswich in late July and early August, 1941, there were twelve primary cases of paratyphoid B fever notified from twelve different addresses in the town. Ten of the patients had not eaten any food away from home for many weeks. By the courtesy of Dr. Hunter, the medical officer of health, and Dr. P. H. Martin of the Emergency Public Health Laboratory Service, cultures of the causal organism recovered from the stools of all the patients were submitted to Felix for phage typing. He found that ten of the patients were excreting *Bact. paratyphosum* B Type 2 and two of them Type 1. Colonel Maddock, a Medical Officer of the Ministry, made local inquiries and ascertained that, although no history of the consumption of one common article of food or drink from one source could be obtained, all the ten patients who had had no meals away from home had, at a material time, a common source of supply of "confectionery" from a shop in which an unattended case was found in the person of a daily domestic helper. There was no other common factor. This woman had continued at work for four weeks after she began to be ill, but ceased on Aug. 13, by which time she had infected her daughter, who lived with her. The helper's duties took her into the shop (she had no access to bulk supplies), and although they did not ordinarily include the handling of confectionery, there is ample evidence that she did this and also assisted in conveying unwrapped confectionery from the bakery on the premises into the shop. The bakery supplied confectionery in bulk to certain other shops, to which no cases were traceable, and all the ten patients implicated were those who were excreting *Bact. paratyphosum* B Type 2. Moreover, the same type was recovered from the stools of the two secondary cases. Of the two primary cases excreting Type 1 bacilli neither had had any dealings with the shop in question. One was staying in another part of Suffolk and the other at a town in the Midlands.

From the beginning of 1941 to the time of the investigation fifteen cases of paratyphoid B fever had been notified from twelve different parishes scattered throughout seven administrative districts in the county (i.e., outside Ipswich), and the conjectured dates of infection of seven of the primary cases fell within the period during which the source of infection was present in the Ipswich shop. Two of the seven were found to be excreting Type 2, the others Type 1. Both the former lived in parishes contiguous to Ipswich and were regular customers of the implicated shop.

All the primary Type 2 cases in Ipswich and the immediate neighbourhood, therefore, were associated with one particular shop in which an excreter of Type 2 was handling foodstuffs at a material time. There was thus complete harmony between the laboratory and the field findings.

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