

# Infantile hypertrophic pyloric stenosis in Belfast, 1957-1969

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**Dodge, J. A. (1975).** *Archives of Disease in Childhood*, 50, 171. **Infantile hypertrophic pyloric stenosis in Belfast, 1957-1969.** Infants with hypertrophic pyloric stenosis born in Belfast during the 13 years 1957-1969 have been reviewed. Their distribution shows a bias towards higher social classes, breast feeding, and primogeniture. Obstetric factors and parental ages seem to be of no importance. More affected infants were born during winter months than would be expected. The overall incidence of infantile pyloric stenosis in this community has fallen during the period under review.

Clinically, the patients started vomiting at a mean age of 22 days and it is recommended that the condition should not be called 'congenital'. The size of the tumour is mainly determined by the size of the patient, rather than by his age or duration of symptoms. Attention is drawn to the occurrence of haematemesis in 17.5% and melaena in 2.9% of infants. Jaundice occurred in 1.8% of patients in this series, and is attributed to the adverse effect of starvation on hepatic glucuronyl transferase activity. Other conditions noted in these patients included inguinal hernia, partial thoracic stomach, and phenylketonuria. Subsequent growth and development were in the anticipated range.

This paper reports some of the findings of a study of infantile hypertrophic pyloric stenosis as it occurred in Belfast during the 13 years 1957-69.

## I. EPIDEMIOLOGY

### Materials and methods

During the period under review there was a total of 107 244 live infants born to residents within the Belfast County Borough. Ramstedt's operation for pyloric stenosis was performed on 289 of these infants, ascertained by examination of hospital records at the three hospitals undertaking children's surgery, Royal Belfast Hospital for Sick Children, Belfast City Hospital, and Ulster Hospital. Infants treated medically have not been included in this survey because the diagnosis cannot be regarded as proven, but they are comparatively few. However, there must undoubtedly be some definite cases among them. The study started in 1964, and data prior to that year were obtained retrospectively. The series was extended back to 1950 for the analysis of birth rank effect, and this added a further 61 patients, but hospital records before 1957 are incomplete, partly owing to the closure of the old Ulster Hospital, and partly to destruction of old files. Analysis

of seasonal variation included a further 171 patients from the Greater Belfast area, making a total of 521. This area includes not only the city itself but also the contiguous areas which are administratively within counties Antrim and Down, and whose populations are drawn by the Belfast hospitals.

Control data were available relating to all infants born to Belfast residents during 1961-68, in respect of social class, maternal age, birthweight, antenatal abnormalities, and type of feeding (J. McA. Taggart, personal communication, 1970). These were directly compared with data pertaining to the 180 of these infants who had surgically confirmed pyloric stenosis. The monthly incidence of live births in Northern Ireland during the 5-year period 1963-67 was used in the analysis of seasonal variation. (The Belfast birth figures were obtainable only in quarterly form, but variation between the quarters was slight; very little monthly variation in birth rates is seen within Northern Ireland as a whole). A random sample of 5024 live births in Belfast during 1962-66 (taken by Dr. J. H. Elwood) was made available for control data relating to birth rank (defined as the number of previous live births). This sample includes 5 of the years during which the infants with pyloric stenosis were born.

Personal follow-up or prospective assessment of 91% of all patients was achieved, the majority of the remainder having emigrated.

### Results

**Incidence.** Accepting that some of the cases have been excluded by the strict criterion of surgical confirmation, the incidence of infantile pyloric stenosis in Belfast is in excess of 2.6/1000 live births. Of the 289 patients, 231 were male and 58 female.

During the first 7 years, 1957–63, the overall incidence was 3.09/1000 live births. The incidence for 1964–69 was 2.22/1000 live births. Statistical comparison between these two periods showed a significant difference ( $0.02 > P > 0.01$ ). This suggests that a real decrease in the incidence of pyloric stenosis has occurred during the last 13 years (Table I).

TABLE I

*Incidence of pyloric stenosis in Belfast County Borough, 1957–1969*

Year	Live births Belfast	Pyloric stenosis	Incidence per 1000 live births
1957	8300	19	2.30
1958	8197	27	3.30
1959	8242	15	1.82
1960	8674	30	3.46
1961	8777	28	3.19
1962	8603	38	4.42
1963	8782	26	2.96
1964	8639	18	2.08
1965	8342	21	2.52
1966	8163	19	2.33
1967	7955	16	2.01
1968	7437	15	2.02
1969	7133	17	2.38

**Seasonal variation.** The incidence of pyloric stenosis by date of birth and also by date of hospital admission was recorded for 521 patients in Greater Belfast from 1950–1969 (Fig.). The results show that the peak incidence of births of affected children occurs in winter (December–January), with another peak in March, while the lowest incidence was in May. The admission pattern approximately followed the birth pattern, with a low incidence of admissions in July, 2 months after the low point in births. The figures for the general population, while showing only minor fluctuations, tend to move in opposite directions (Table II). It is evident that during the 6 ‘winter’ months, November to April, the number of children born who develop pyloric stenosis is in excess of the expectation, while during the ‘summer’ months, May to October, fewer affected infants were born than would have been anticipated. The difference between observed and expected incidence for these two 6-month periods is significant ( $P < 0.01$ ).

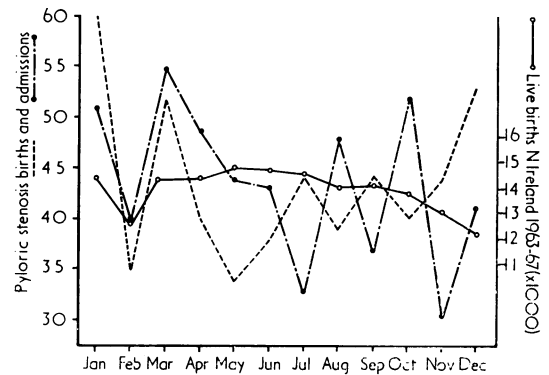


FIG.—Monthly incidence of infantile hypertrophic pyloric stenosis in Greater Belfast, 1950–59, compared with monthly index of live births for Northern Ireland 1963–67.

**Birth rank.** The birth rank of 350 Belfast infants with pyloric stenosis, born between 1950 and 1969, was compared with the distribution of a random sample of 5012 Belfast infants born between 1962 and 1966 (Table III). It is clear that a statistically significant excess of first-born infants had operations for pyloric stenosis.

**Social class.** The social class distribution of parents of affected infants born during the years 1961–1968 was compared with that of all parents of Belfast infants born during the same period (Table IV). A strong bias towards higher social classes was observed.

**Parental ages.** The age distribution of mothers of affected children did not differ greatly from the distribution in the general population. No control figures for fathers' ages were available. In the pyloric stenosis series the fathers' ages were slightly greater than the mothers'.

#### Pregnancy and labour.

**Birthweight.** The birthweights of 189 infants with pyloric stenosis born to Belfast residents during the period 1961–68 inclusive was compared with the birthweights of all liveborn Belfast infants in the same period. The smallest infant in the series weighed 1.80 kg, and the largest weighed 5.43 kg.

**Antenatal abnormalities.** The incidence of antenatal abnormalities in the general population is not known. Data obtained from Belfast County Borough show that in 1961 such abnormalities were present in the pregnancies of 994 out of

TABLE II

*Distribution of 521 infants with infantile hypertrophic pyloric stenosis (IHPS) by month of birth and month of operation, 1952-1969*

Month	N. Ireland births 1963-67		IHPS births		IHPS operation	
	No.	%	No.	%	No.	%
January	14 472	8.60	60	11.52	51	9.73
February	12 757	7.58	35	6.72	40	7.63
March	14 395	8.55	52	10.00	55	10.50
April	14 472	8.60	40	7.68	49	9.35
May	15 005	8.92	34	6.52	44	8.40
June	14 809	8.80	38	7.28	43	8.21
July	14 676	8.72	44	8.44	33	6.30
August	14 147	8.41	39	7.49	48	9.16
September	14 173	8.42	44	8.44	37	7.06
October	14 971	8.30	40	7.68	52	9.92
November	13 069	7.76	42	8.06	31	5.92
December	12 346	7.34	53	10.17	41	7.82
Total	169 292	100	521	100	524	100

TABLE III

*Distribution of Belfast infants with infantile hypertrophic pyloric stenosis, 1950-69, according to birth rank, compared with distribution of random sample of liveborn Belfast infants, 1962-66*

Birth rank	IHPS (Belfast only)		Random sample of live births Belfast, 1962-66	
	No.	%	No.	%
1	147	42.0	1407	28.1
2	70	20.0	1287	25.7
3	50	14.3	837	16.7
4	40	11.4	577	11.5
5	16	4.6	344	6.9
6	3	0.9	218	4.3
7	8	2.3	137	2.7
8	16	4.5	205	4.1
Total	350	100.0	5012	100.0

$\chi^2 = 42.7$ ;  $df = 7$ ;  $P < 0.001$ .

TABLE IV

*Distribution of 180 Belfast infants with infantile hypertrophic pyloric stenosis according to parents' social class, compared with distribution of parents' social class for all liveborn infants in Belfast County Borough, 1961-68*

Social class	IHPS, 1961-68		Live births, 1961-68	
	No.	%	No.	%
I	18	10.0	1 626	2.6
II	23	12.7	4 106	6.5
III	68	37.8	33 962	54.0
IV	36	20.0	7 585	12.1
V	28	15.6	15 693	24.9
Not known and illegitimate	7	3.9	3 726	8.9
Total	180	100.0	66 698	100.0

$\chi^2 = 72.8$ ;  $df = 6$ ;  $P < 0.001$ .

8777 liveborn infants (11.3%), whereas in 1968 the proportion was 2160 out of 7437 (29.0%). This strongly suggests that diagnostic standards and definitions of abnormality have changed during the 8-year period.

However, it was possible to compare specific complications of pregnancy in 101 matched pairs of infants, one of each pair having undergone operation for pyloric stenosis. Matching, for month of birth, sex, parental ages, social class, and birth rank was performed by records staff of the three local authorities concerned.

There was no striking difference between the two groups to suggest that pregnancy complications play any part in the aetiology of pyloric stenosis. When attention was directed to specific gastrointestinal symptoms, it was noted that 5 of the mothers of infants with pyloric stenosis complained of considerable abdominal pain during the pregnancy, but none of the matched control mothers were similarly affected.

**Type of Feeding.** Between 1961 and 1968 the proportion of Belfast infants who were breast fed at the age of 1 week fell from 29% (of which nearly one-third were supplemented with bottle feeds) to 6.6% (of which about one-third were again receiving supplements). Those infants who were breast fed with or without supplements at the age of 1 week represented 16% of infants born between 1961-68 inclusive. Only 11% were wholly breast fed at one week.

Of the 181 infants with pyloric stenosis born to Belfast parents between 1961-68, 40 were breast fed for more than a week, of which 3 received supplements. This rate of 22% is higher than that expected from the general population figures. The difference was statistically significant and becomes more so when only those infants wholly breast fed at one week are considered (Tables V and VI).

TABLE V

*Infants wholly or partially breast fed at one week*

	Breast fed		Other		Total
	No.	%	No.	%	
Belfast, 1961-1968	10 616	15.9	56 082	84.1	66 698
Pyloric stenosis, Belfast, 1961-1968	40	22.1	141	63.9	181

$\chi^2 = 4.9$ ;  $P < 0.05$ .

### Discussion

**Incidence.** The observed incidence is similar to that in other European series. In Great Britain

TABLE VI  
*Infants wholly breast fed at one week*

	Breast fed		Other		Total
	No.	%	No.	%	
Belfast, 1961-1968	7202	10.8	59 490	89.2	66 698
Pyloric stenosis, Belfast, 1961-68	37	20.4	144	79.6	181

$\chi^2 = 16.1$ ;  $P < 0.001$ .

the incidence is generally of the order of 3/1000 live births though a recent survey in the South East of England found only about 2/1000 live births, including patients treated medically (Carter and Evans, 1969). This may reflect a decreasing incidence, which has also been noted in Sweden where the frequency fell from 4 to 3/1000 live births in a decade (Wallgren, 1960). However, an opposite trend has been noted in West Germany (Stroder, 1962), though that report was concerned with only one hospital and may be explicable in other ways. A study undertaken in the North East of Scotland compared the incidence of infantile pyloric stenosis in the year 1938 with that observed in 1953, and found an apparent increase from 2.37 to 4.5/1000 live births. This was attributed to better diagnosis rather than to a true increase (McLean, 1956). The present study shows a decreasing incidence in Belfast over the period under review.

A male: female sex ratio of 3.3:1 was observed by Bell (1968) and by Fanconi and Wallgren (1952). A sex ratio as high as 6:1 was found by Rinvik (1940), but this is so high that it raises a suspicion that clinicians may have been reluctant to diagnose the condition in females. The present sex ratio of 4:1 in Belfast is reduced to 3.47:1 when the whole series of 521 patients is considered.

**Seasonal variation.** The seasonal variation found, i.e. an increased frequency among infants born during the winter, is difficult to explain. Kwok and Avery (1967) found that in a single hospital in Washington, D.C. a larger number of babies with pyloric stenosis were admitted during April-May, and October-November, than they would have expected. However, they compared the observed admission rate with the birth rate for each month of the year. It is evident from their illustration that the peak monthly incidence of pyloric stenosis follows the peak monthly birth rate after an interval of 1-2 months: which is exactly what would be expected of a condition which usually presents at the age of 4 to 6 weeks. Nevertheless, the extent of the seasonal variation

shown in Kwok and Avery's series is considerable. It is possible that local factors which directed a majority of affected infants to the Children's Hospital, Washington, D.C. at certain times of the year, and to alternative hospitals at other times. Moreover, there is marked variation in monthly admission rates from year to year. The authors offered no explanation for their findings. The increased winter incidence in Belfast suggests that infective factors could possibly be involved, but there is no evidence to support this hypothesis. Herwig, *et al.* (1962) undertook extensive virological studies in affected infants, with negative results.

**Primogeniture.** It has been traditionally believed that first-born infants are unduly liable to develop pyloric stenosis, but several authors have questioned this assumption. Reported series have given conflicting results. In this series the strikingly higher incidence of the condition in first borns is in keeping with previous accounts. It should be noted that in a recent series of 200 patients from Glasgow, only 30.5% were first born compared with 32.7% for all Scottish births (Dougall, 1969). It is possible, of course, that the population served by the hospital concerned is not representative of the whole of Scotland, nor even of Glasgow, in respect of family size.

**Social class.** No explanation for the social class bias is apparent. Certain occupations appear to be associated with a high risk of pyloric stenosis in the offspring. The children of physicians were claimed by Rommel (1910) to be often affected, and this series appears to support that view. There were 8 doctors' children out of a total of 526, i.e. 1 in 67. There were 18 children of policemen, which also seems to be a high proportion. It was not possible with available data to calculate accurately whether this represented an increased risk to children of these professional groups, but a rough approximation suggests that it may be of the order of 3 and 3½ times for doctors and policemen, respectively.

**Parental ages.** The slightly lower incidence of mothers aged over 35 years may perhaps be explained by socioeconomic factors, because infants with pyloric stenosis tend to come from the higher social classes, where families are smaller and childbearing ceases at an earlier age. However, if maternal inexperience and anxiety are aetiologically related to infantile pyloric stenosis, as the higher incidence in firstborns suggests, then one might expect to find an increased number of young women in the series.

**Pregnancy.** The slight excess of larger infants in the series may also reflect the bias towards higher socioeconomic class which has been referred to above. Clearly, no important abnormalities of pregnancy were detected in the mothers of affected babies.

**Feeding.** The fact that the frequency of breast feeding in Belfast has fallen so rapidly makes it unwise to place too much emphasis on the finding of a significantly greater number of breast-fed infants than one would expect. However, a possible explanation is that some factor may be transmitted in breast milk which plays a minor contributory role in the genesis of pyloric stenosis. The falling incidence of the condition referred to above has occurred at a time when the breast feeding rate has also fallen. Although there are no population figures available for breast feeding in relation to social class, recent experience in the Royal Maternity Hospital, Belfast, suggests that breast feeding is commoner among mothers of the higher social classes, and it has been shown above that parents of these same classes also appear to have a disproportionately large number of infants with pyloric stenosis.

Hospital records and maternal recollections were not felt to be sufficiently accurate to allow for analysis of feeding according to time schedule. However, Gerrard, Waterhouse, and Maurice (1955) found that infants fed on a 3-hourly schedule tend to develop symptoms of pyloric stenosis at a younger age than infants fed 4-hourly.

## II. CLINICAL FEATURES

### Ages at onset of symptoms and at operation

Data relating to age at onset of vomiting were analysed for 489 patients. There were 79 (17%) who started to vomit during the first week of life, though in many of these the vomiting was not initially projectile. Two-thirds of the patients (322) started vomiting during the first 4 weeks, and in only 6 patients (1.2%) was onset of vomiting delayed until the third month or later. Onset was thus predominantly during the first 2 months of life. The mean age at which vomiting began was 22 days.

The majority of patients in this series came to operation between the fourth and seventh weeks of life. Only one of these children was operated upon during the first week, but 13 were over 3 months old at operation. The mean age was 42 days.

In 45% of babies vomiting had been occurring for less than 2 weeks before operation, and in only 14% was the history more than 5 weeks. Frequently the history stated that the infants had an abrupt onset of projectile vomiting which was so severe that they were diagnosed and operated upon within a few days. The mean duration of symptoms before operation was 20 days.

These findings confirm that infants with pyloric stenosis do not usually vomit from birth, but start at the age of a few weeks.

It is possible that the tumour may be present before the onset of vomiting; but there are several well-documented instances of an infant undergoing laparotomy in the first few days of life for an intestinal obstruction and subsequently developing pyloric hypertrophy (e.g. Ladd, Ware, and Pickett, 1946; Witte, 1948; Dodge, 1970). Though congenital cases undoubtedly occur, the characteristic later onset of vomiting suggests that postnatal tumour development may be the rule. The adjective 'congenital' should, therefore, be omitted and the condition more properly defined as 'infantile hypertrophic pyloric stenosis'.

#### Tumour size

McKeown, MacMahon, and Record (1951), in a survey of 478 case histories at Birmingham, found that 'small' and 'large' tumours were most likely to be observed at operation in younger and older infants, respectively. They suggested that this evidence strongly supported the view that tumours develop after birth. Subsequently, Gerrard *et al.* (1955) found that a close correlation existed between the ages of their 51 patients at operation and the external volumes of the tumours.

Careful measurement of tumour length and breadth was obtained in 100 unselected Belfast patients, using calipers and a steel rule. Data derived from measured tumours, with the patients' ages, duration of symptoms, birthweights, and weights at operation were put onto standard punch

cards and a correlation analysis was performed in the Computing Laboratory at Queen's University, Belfast (Table VII). No significant relation to the infant's age at operation was found, nor was volume significantly related to duration of symptoms. A closer association existed between the infant's weight and tumour volume. This relation was significant at the  $P < 0.05$  level and was almost the same whether birthweight or weight at operation were considered.

This series failed to confirm the findings of Gerrard *et al.* (1955). It suggested that the infant's birthweight (like the closely related weight at operation) is more closely related to tumour volume than either age or duration of history.

#### Haematemesis and melaena

Streaks of blood in the vomitus of infants with pyloric stenosis are often attributed to gastritis secondary to gastric stasis. In 2 infants of the present series who were examined post mortem there was a history of blood stained vomiting, and in both superficial ulceration of the oesophagus was present. No mention is made of hiatus hernia but one of the infants had a brother with that disorder and it is possible that oesophageal reflux and ulceration may have been present on such a basis. In other babies who bled, the source of the bleeding is uncertain.

Haematemesis, usually as 'coffee grounds' or brown streaks, but sometimes in the form of fresh blood, was recorded in the case histories of 92 out of 526 patients (17.5%)

Melaena stools were observed in 15 patients (2.9%). The bleeding appeared to be derived from the stomach or oesophagus rather than from the duodenum in most cases, inasmuch as haematemesis was much more frequent than melaena. The most likely explanation is that gastric stasis and gastro-oesophageal reflux led to superficial ulceration of the gastric or oesophageal mucosa.

TABLE VII  
Correlation matrix for volume of pyloric tumour and other variables (100 cases)

	Volume	Age	Duration	Birthweight	Weight
Volume	1.0000	0.1719	0.8939	0.2908*	0.3528*
Age	0.1719	1.0000	0.5524*	0.0503	0.5625*
Duration	0.0939	0.5524*	1.0000	0.1155	0.3815*
Birthweight	0.2908*	0.0503	0.1155	1.0000	0.5054
Weight	0.3528	0.5625*	0.3815*	0.5054*	1.0000

\*Significant,  $P < 0.05$ .

### Jaundice

One of the most interesting complications occasionally encountered is hyperbilirubinaemia. It was recorded in 8 patients of the present series (1.5%). Records of 4 other jaundiced infants who resided in other parts of Northern Ireland were found at the Royal Belfast Hospital for Sick Children and were also studied.

The incidence of this complication in reported series varies from 5 out of 29 patients, 17% (Sienawska and Wroblewska-Kaluzewska, 1964) to 30 out of 1160, 2.6% (Schärli, Sieber, and Kiesewetter, 1969), of which the latter is probably the more accurate estimate. That there is a causal relation between icterus and pyloric stenosis is indicated by the fact that the jaundice fades rapidly after operation in the majority of cases, and that when it does not there is usually some other reason such as transfusion reaction (Chaves-Carballo, Harris, and Lynn, 1968). In one patient jaundice and vomiting both persisted after Ramstedt's operation, and at laparotomy 7 days later a massive blood clot around the pylorus was thought to be causing continuing obstruction.

Various suggestions have been put forward to explain the occurrence of jaundice. There is no evidence that the common bile duct is obstructed by the tumour, and it is noteworthy that the jaundice is almost entirely due to unconjugated bilirubin. It was suggested that breast-milk jaundice was the true diagnosis in a series of 8 infants with jaundice and pyloric stenosis (Marion, Daudet, and Friedel, 1967) but of the 12 patients in the present series, only one was being breast fed at the time of admission to hospital while 6 were bottle fed from birth. Other factors which might be contributory include prematurity (present in 4 of these 12 infants) and Rhesus blood group incompatibility (1). A similar unconjugated hyperbilirubinaemia is sometimes observed in other forms of high intestinal obstruction. Recent observations of the adverse effect of starvation on glucuronyl transferase activity in Gilbert's syndrome (Owens and Sherlock, 1973) suggest that a relative deficiency of the enzyme may be brought to light by vomiting and its nutritional consequences. The high incidence of Gilbert's syndrome in the general population may be as high as 4% which is actually lower than the observed incidence of jaundice in pyloric stenosis (D. Owens, personal communication, 1974).

### Associated disorders

These were of very diverse nature and degree of severity. Of interest is the large number of babies

(12) with inguinal herniae. Though no comparative data for the general population are available, it suggests that the vomiting in these infants may cause recurrent increases in abdominal pressure sufficient to produce indirect inguinal herniation.

There were 5 infants with hiatus hernia (partial thoracic stomach). This condition is a congenital malformation which is present from birth, and should not be regarded as secondary to the pyloric obstruction. The incidence in this series is approximately ten times that in the general population (Carré, 1959).

Two children in this series had phenylketonuria. The incidence of this condition in Northern Ireland is 1:10 000 live births (Carson, Carré, and Neill, 1968). Though no conclusions can be drawn from 2 patients, others have also observed an apparently increased incidence of pyloric stenosis among phenylketonurics (Koch *et al.*, 1973; C. O. Carter, personal communication, 1968). Babies with phenylketonuria frequently vomit in the absence of any demonstrable gastrointestinal lesion. It is possible that vomiting from some nonobstructive cause such as partial thoracic stomach or phenylketonuria may predispose to tumour development.

### Subsequent growth and development

Although Carter has suggested that children who had infantile pyloric stenosis tend to be large and muscular (C. O. Carter, personal communication, 1969) there is no evidence from this series that they deviate from the normal distribution of height and weight.

These parameters were measured at follow-up of 246 children (185 boys and 61 girls) whose ages ranged from 6 months to 17 years. The measurements were plotted on standard growth charts prepared by Tanner, Whitehouse, and Takaishi (1966). The measurements fell mostly within the expected range and examination of the growth charts showed a wide symmetrical scatter. No assessment of muscularity was attempted.

I thank the consultant paediatricians and paediatric surgeons of Belfast, all of whom allowed me to review their patients. I am also indebted to Dr. J. McA. Taggart, Medical Officer of Health for Belfast County Borough, and his staff for providing epidemiological data, and selecting many of the matched pairs. Others were equally carefully chosen by the records staff of County Antrim and the Castlereagh division of County Down, whose respective Medical Officers of Health were Dr. W. Bamber and Dr. S. Hayes. Dr. J. H. Elwood allowed me to refer to his data on Belfast children and Dr. J. D. Merrett gave statistical advice. Particular thanks are due to Professor I. J. Carré for his encouragement and advice throughout the study.

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