Holy Island: A demographic, genetic and medical population study

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HOLY ISLAND : A DEMOGRAPHIC, GENETIC AND MEDICAL POPULATION STUDY

R. A. CARTWRIGHT

The thesis consists of three chapters, concerned with demographic genetic and medical population studies respectively. In the first chapter the social history of the island is outlined and the historical demography, as deduced principally from census and parish records is considered. Thus the demographic composition of the present day islanders is established in detail and these data provide the bases for genetic studies.

The second chapter provides detailed genetic parameters for the contemporary population. These include the following : blood groups, serum proteins, isoenzymes, PTC tasting, dermatoglyphics and BAIB excretion. Possible explanations for the observed gene frequencies are sought, frequencies which, in toto, render the population of Holy Island unique. These explanations involve both geographical and historico-demographic factors.

In the third chapter the results obtained by population screening procedures are outlined. These include : red cell haemoglobin, serum uric acid, serum cholesterol and blood sugar levels, and their significance within the population is discussed.

Major themes which run through the thesis and which serve to unify its constituent sections include : the use of surnames, a series of island sub-populations and the use of interrelationships.

HOLY ISLAND

A Demographic, Genetic and Medical Population Study.

by

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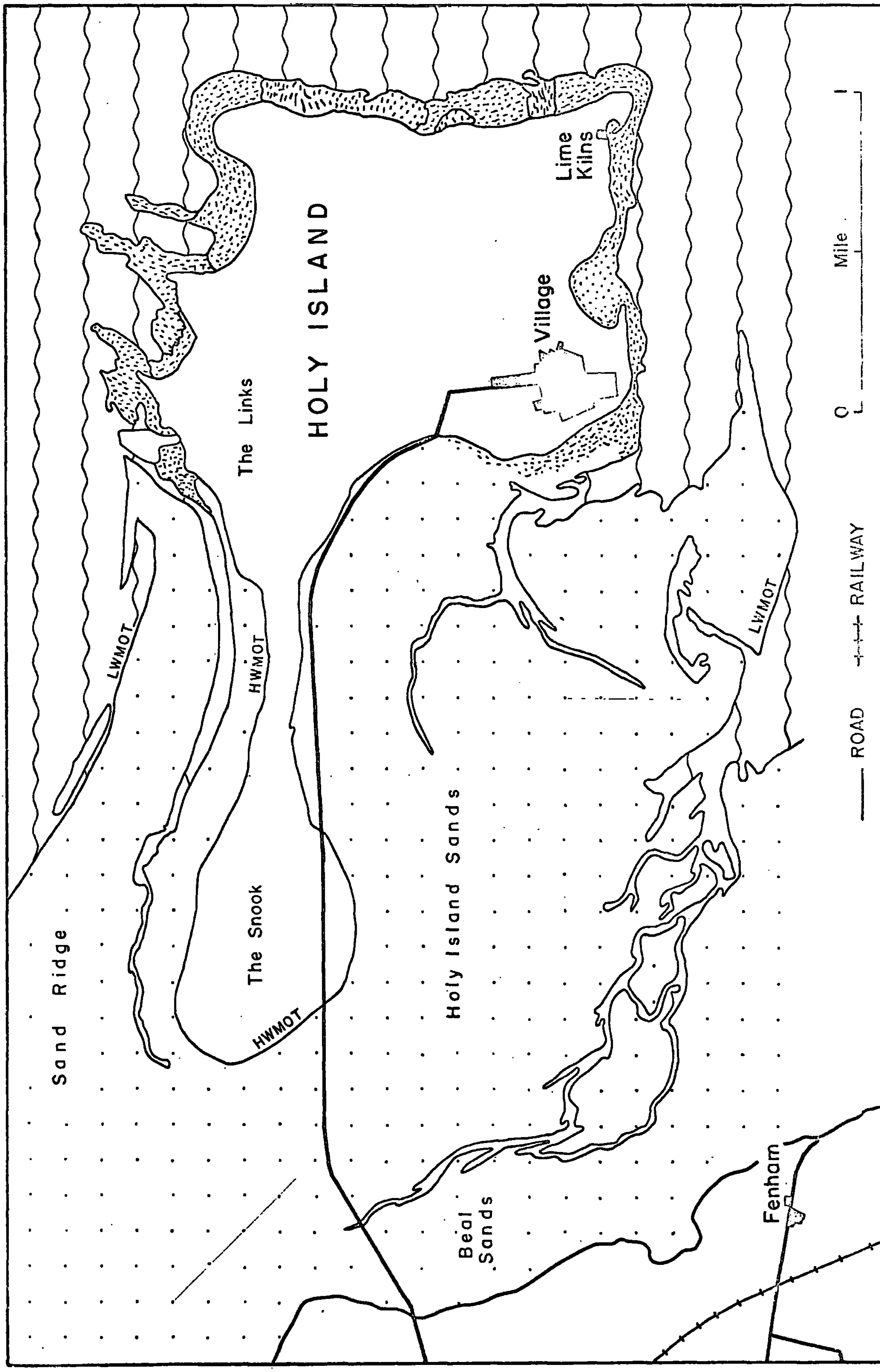
Thesis submitted for the degree of Doctor of Philosophy

Department of Anthropology

University of Durham 1973


HOLY ISLAND
The Links
Lime Kilns
Village
Holy Island Sands
The Snook
Sand Ridge
Beal Sands
Fenham
LWMOT
HWMOT
HWMOT
LWMOT
ROAD
RAILWAY
0
Mile
1

CONTENTS

FIGURES

FOREWORD

These studies are the product of fieldwork and analysis commenced during the autumn of 1969. The aim is to investigate the population of Holy Island by using demographic, genetic and medical techniques. The thesis consists of three chapters, two appendices and a bibliography. The chapters are linked by short collations at the end of each chapter, subdivision or part.

There are some difficulties associated with presenting three widely ranging topics as a whole unit. These limitations centre around the problem of interlinking each item into an ongoing piece of work. However an attempt has been made to continue certain themes from one chapter to the next. The demographic subdivisions and the study of inter-relationships are mentioned in all three chapters. Further a surname analysis links the first two chapters and a study of the genetic attributes the last two, each of these topics being dealt with as a part of each chapter.

Chapter summaries, a terminal synthesis and a series of definitions complete the general plan of the thesis.

ACKNOWLEDGEMENTS

I have received invaluable help from many sources during the course of this work. First I should like to thank the inhabitants of Holy Island who helped by allowing me to test them and especially Mrs Minnie Bill and her husband the Reverend Denis Bill without whose kindness and help none of this would have been possible. Of the others I should like to mention : Dr.W.Cowan for his help with the tests in chapter three,Mrs Shelagh Cowan for her study of the social history of the island,Dr.D.Byers of Belford,Mrs A.Carline and other typists at Newcastle University,Mrs D.Robinson and Mrs B.Elvin at Durham University, Mr M.Carr of the Anthropology Laboratory at Durham University,Dr.Gunson of Lancaster National Blood Transfusion Service for his gifts of antisera,Dr.A.E.Mourant and Mr D.Tills for their help in testing blood samples from the island,the trustees of the Eleanor Peel Awards for a grant towards equipment and the Medical Research Council for a personal scholarship. Finally I would like to express my gratitude to Dr.D.F. Roberts for his help and encouragement and to my supervisor Professor Eric Sunderland for his patience,kindness and invaluable support.

NUMERICAL ANALYSIS

All the calculated proportions have been rounded off so as to summate to unity. None,one or two decimal places have been used in the figures. The number used varies and depends on the complexity of the tables in which they are used, the aim being to present the figures as clearly as possible. All approportioning can be regarded as an estimate whatever the number of decimal places used. The frequencies are used for easy comparison between two sets of data of different sample size. Where frequencies have been required for other purposes three decimal places have been used; for example in the chi-squared tests.

The chi-squared test results are not given in the tables if the non-significant results exceed a probability of 10%. The results when given are rounded off to two places of decimals in these tables.

When percentages do not summate to a hundred or frequencies to unity the results are those of other authors and as such have not been altered.

New Couples

This is the term used to refer to certain couples whose births are not recorded on the island,but who produce children on the island. There are two types of new couple; those whose children and later descendants remain in the breeding population on the island and those whose descendants leave the island.

Non-contributory and Contributory Populations

These are the two basic aspects of the genetic community on the island. The non-contributory population comprises those parents and their offspring who do not form a second generation on the island. The contributory population,on the other hand,is the group whose children are parents in later cohorts. This second group may be regarded as an effective population,in the genetic sense of the word. The contributory population is founded by a fixed number of new couples. The terms 'core' and 'transient' populations refer largely to the contributory and the non-contributory groups.

Coefficient of Relationship (R)

This is the crude probability,first suggested by Wright,that two people will have identical genes because of a common ancestor. Here it is an approximation calculated as the summated value of $(\frac{1}{2})^N$ where N is the number of interlinking genealogical steps. The value of R in this thesis is calculated in a simple fashion using a summation of the same values of N.

The coefficient of kinship is most usually used,this is half the value used here.

DEFINITIONS

Throughout this thesis the following words and phrases are found which have specific meanings.

Cohort or Cohort Decade

This is a method of arbitrarily dividing up the reproducing population on Holy Island. This is done by assembling nuclear families whose eldest child was born within certain fixed limits. Cohort 1 is between the years 1578 and 1579, cohort 2 between 1580 and 1589 and so on until cohort 40 between 1960 and 1969. All the years given are inclusive. **This is not the usual model used in cohort analysis, normally marriages are referred to and not births.**

Endogamy and Exogamy

In the context of this thesis, endogamy refers to marriages of partners both of whom are from the village on the island. Exogamy is when one partner is from the island and one from elsewhere. They can refer to either places of birth or to where the two people were living immediately prior to the marriage. Unless a statement is made to the contrary they are taken to refer to places of birth. Endogamy does not necessarily mean that the couple are close blood relatives.

Marriage Distance

In an exogamous marriage this is the distance between the birth places of spouses. It is measured by foot and bridle paths from Beal Point, the nearest point on the mainland. This place is some three miles from the island village.

CHAPTER ONE

The Genetic Demography - Historical and Contemporary.

Part (a)

Introduction and History

The Geographical Setting

Holy Island or Lindisfarne lies off the coast of rural Northumberland some eight miles South of Berwick-on-Tweed. The island is roughly L-shaped. Figure (1) shows the island from the mainland looking East; the nearer North-Western part of the island, covered in sand dunes, is called the Snook. Figures (1) and (2) were taken prior to the construction of the causeway and the metalled road linking the village with the mainland.The normal vehicle track across the sands may be seen in these two photographs. The North of the island in Figure (1) can be seen to the left as rocky promontories jutting into the sea and enclosing two coves. The centre of the island South of the coves is farmed; there is rough land near the dunes, arable and pasture further South. Figure (2) shows the full extent of the sand dunes and the site of the farm just to the right (North) of the village. Two faulted ridges of dolerite (Whin sill) dominate the South of the island. The village,church and priory lie under the Westerly ridge (the Heugh) whilst on the Easterly crag (Beblowe) stands the castle. Between the ridges is a shallow bay,the Ouse. Immediately to the West of the island lies another piece of Whin sill which is connected to the larger island at low tide (Saint Cuthbert's Island). Figure (2) also shows the narrow channel separating the island from the mainland and in the distance the Cheviot hills. Figure (3) shows the place names and main features of the island as recorded in the first edition of the Ordnance Survey series of maps (circa 1860). Figure (4) shows the village in more detail and also the bare appearance of the island with its general lack of trees.

The deep channel which divides the island from the mainland was bridged in 1959 at a place where the ford had been. This extends the time

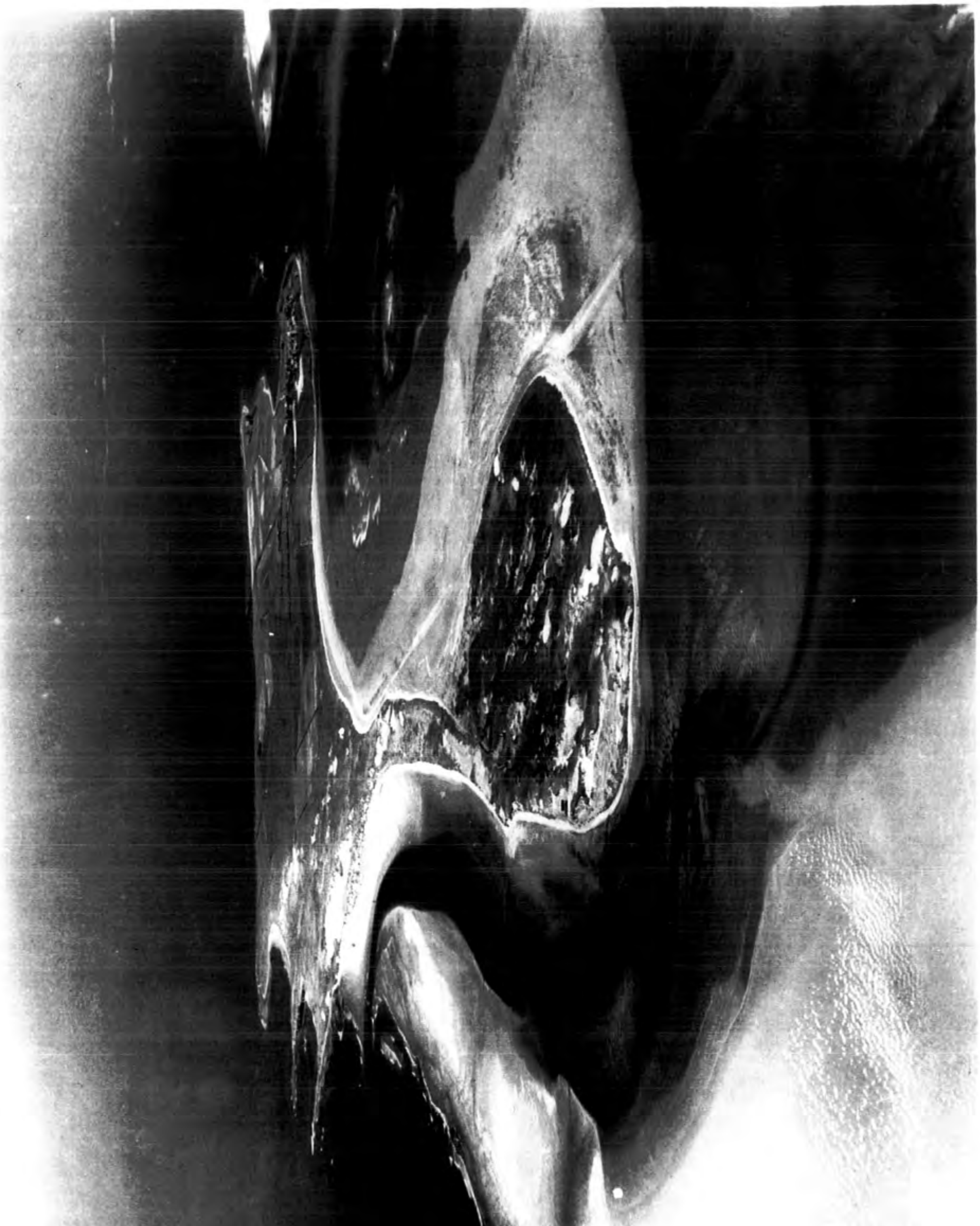


Figure (1)

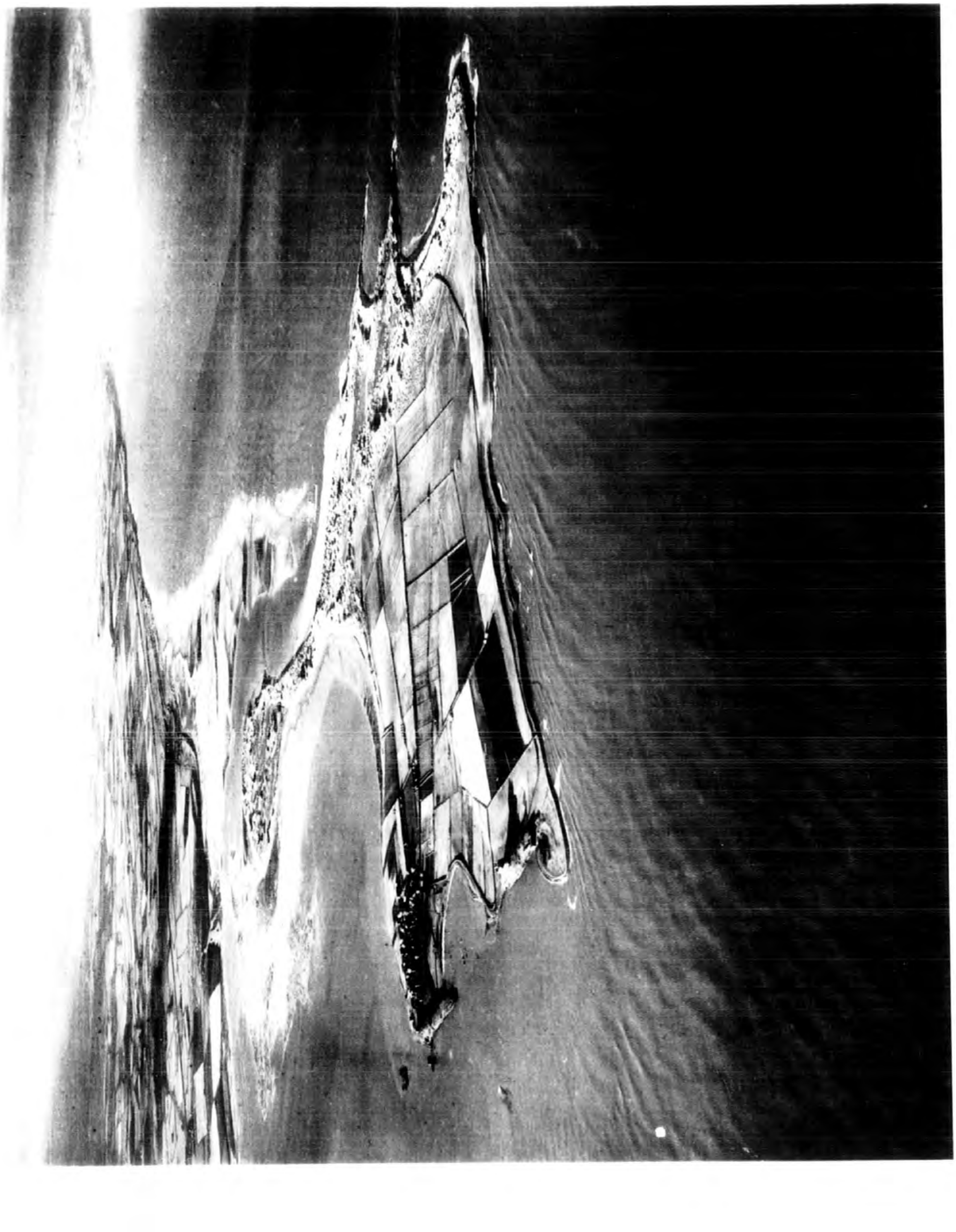
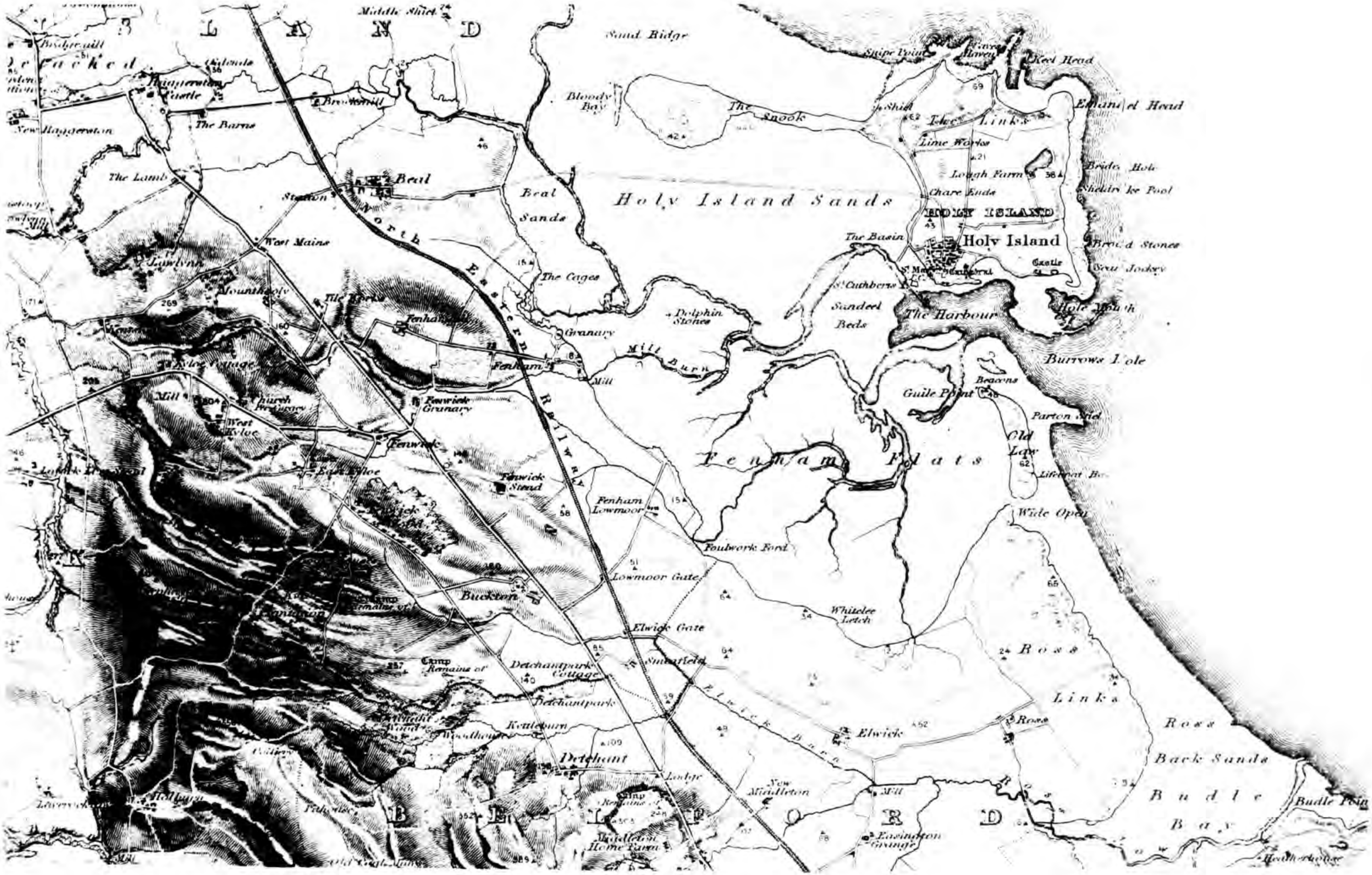


Figure (2)



Holy Island Sands
Holy Island
HOLY ISLAND
The Harbour
The Snook
Sand Ridge
Bloody Bay
Snipe Point
Keel Head
Lime Works
Lough Farm
Chare Ends
The Basin
Castle
Sandeel Beds
Burrows Hole
Guile Point
Beacons
Parton Steel
Old Law
Wide Open
Fenham Flats
Dolphin Stones
Mill Burn
Beal
Beal Sands
The Cages
Granary
Fenham
Fenwick Granary
Fenwick
Fenwick Stead
Fenham Lowmoor
Foulwork Ford
Lowmoor Gate
Whitelee Letch
Elwick Gate
Elwick
Elwick Burn
Bucktin
Detchantpark Cottage
Detchantpark
Kettleburn
Detchant
Lodge
New Middleton
Mill
Easington Grange
Middleton Home Farm
Ross
Ross Links
Ross Back Sands
Budle Bay
Budle Point
Heatherhouse
North Eastern Railway
Station
West Mains
The Lamb
Mounthooly
Tile Works
West Kyloe
East Kyloe
Church
Haggerston Castle
The Barns
New Haggerston
Middle Ridge
Brockmill
Bridgemill
Camp Remains of
Old Coal Mines
Holburn

Figure (4)

the island is accessible from the mainland. The island is now isolated for two to six hours per tide depending on the wind and season. A metalled road connects the village with the mainland and runs to the South of the Snook (see frontpiece).

The greater part of the island is Carboniferous and a quarry near Emanuel Head has in the past provided stone,coal and limestone.In connection with the latter an old wagonway can be seen running down the East of the island to some limekilns to the East of the castle.

The climate is milder than the mainland part of Northumberland.

A seasonally appearing pond (the Lough) attracts many migrant sea birds as do the cliffs on the North side of the island. The whole North part of the island is a reserve administered by the Nature Conservancy ('Lindisfarne National Nature Reserve' a pamphlet issued by the Nature Conservancy).

The Social History of Holy Island

Lindisfarne has been described by Bede as " Twice an island and twice a continent in one day ". All the sources of evidence suggest that the island has been inhabited by a series of populations.

A stone adze of the Tardenois culture,flints and hearthsites have been found in the Snook. Little else is available until the post-Roman period. Bede recounts that Aidan established a monastery of the Celtic Church on the island in 635 at the invitation of the King of Northumbria. There followed from this time a period of intense evangelical activity which made the monastery of Lindisfarne a major centre of Christian teaching in Britain.

The Vikings first raided the island in 793 (Simeon 1 and the Anglo-Saxon Chronicle) but the monks and their attendant population remained on the island until finally driven off by the attack of Healfdene in 875 (Simeon 2). The monks removed all their remaining treasures from the island including the body of Cuthbert,the head of Oswald,the Lindisfarne Gospels and a Liber Vitae.

The Norman conquest resulted in the establishment of a Cathedral church at Durham to house the body of Cuthbert,in accordance with their policy of continuing the traditions of the English. Another facet of this was the erection of a Benedictine Priory on Lindisfarne and naming the island 'Holy Island'. The house on the island was administered by the monks of Durham.

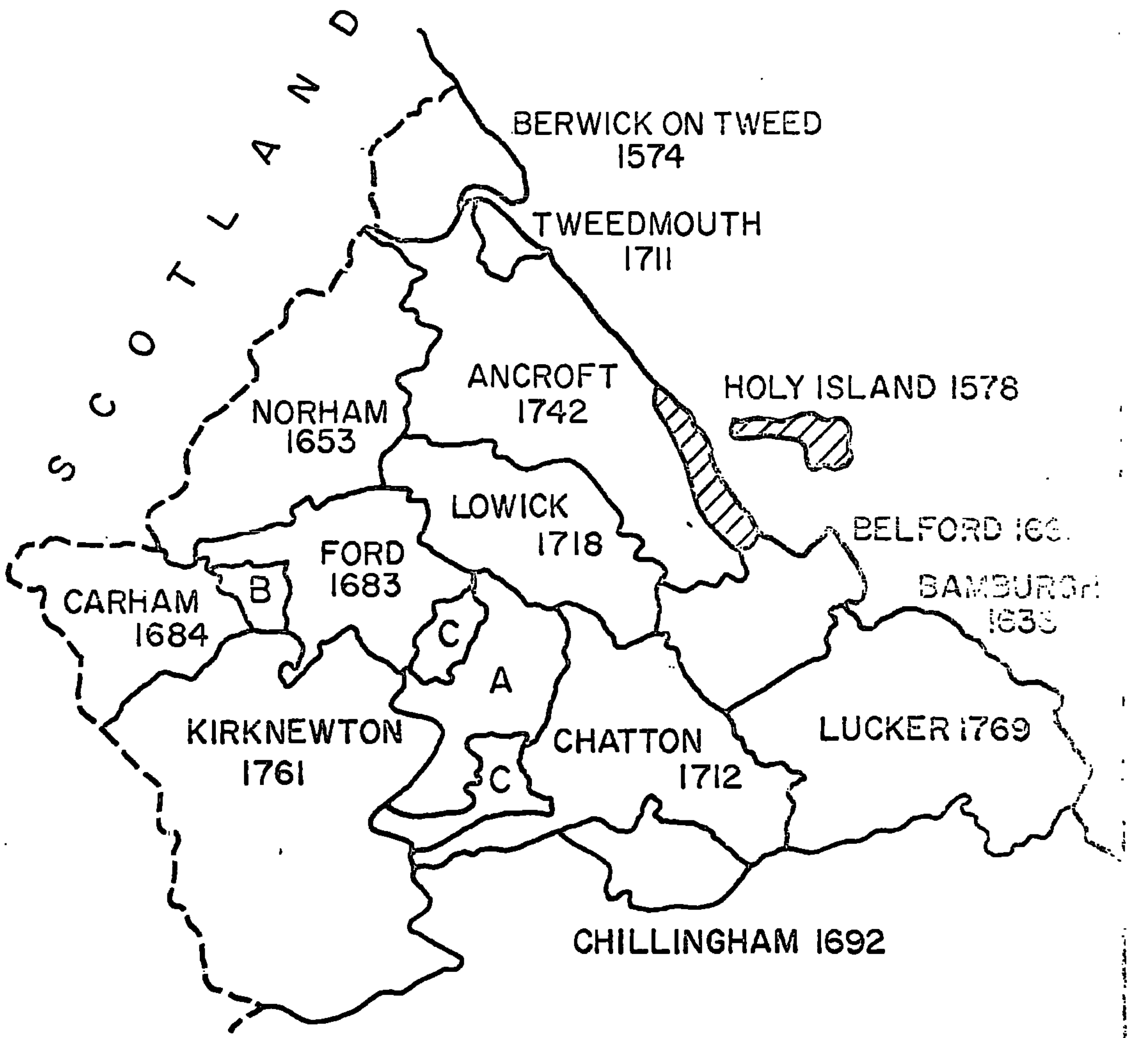
The feudal system in Northumbria was less strict than further South, due to the proximity of the Scottish border and the considerable distance from regal authority. Also there was a sparse distribution of Norman families in North Northumberland,much of the land being church property farmed by local tenants.

From this time the parochial structure of the area originated. A church was built on the island by the middle of the twelfth century. The fabric today contains some Saxon stone work. In 1145 the Pope confirmed that the island church was the mother church of the chapelries of Kyloe, Lowick,Ord,Ancroft and Tweedmouth. By 1200 Fenham was added to the others (Raine 1852). This established the pattern of lands associated with the mother church and also indicates the distribution of estates owned by the Priory. From this arose the administrative area of Islandshire which was part of Durham county until the mid-nineteenth century.

Figure (5) shows the boundaries of the parishes towards the end of the nineteenth century. The dates show the commencement of the registers. The dates for Lowick,Ancroft and Tweedmouth mark the virtual registrational autonomy of these chapelries with the near exclusion of all entries referring to these areas in the registers of Holy Island. The shaded areas on the map represent the island along with Fenham,Broomhouse and Goswick which were retained by the mother church until the end of the last century. This has the effect that these mainland areas were mainly served by the registers of Holy Island. None of the mainland chapelries were formally dissociated from the island until the late nineteenth century. Now 'Holy Island parish' consists of the island alone.

As early as the twelfth century mainland families had residences (garths) on the island. In addition the religious house must have had a considerable attendant population on the island; meat was said to be reserved for the aged and children, commercial fishing was started during this period and the cultivation of hay,flax,beans and onions is recorded. In the fourteenth century the priory accounts list payments to smiths, masons,carpenters,gardeners,gosherds,millers,swineherds,cowherds,clerks and women (Raine 1852).

NORTH NORTHUMBERLAND: Showing the Parish Boundaries and the dates at which the Registers start



A. DODDINGTON 1688

B. BRANXTON 1746

C. WOOLER 1692

Parts included in the Holy Island Registers

Fig 5

There are several reasons why the gentry of Northumberland should have houses on the island. The weather was milder. The priory was a rich and well stocked establishment with its brewhouse and bakehouse and well defended stores. The Scots' raiding parties usually avoided the island; they were superstitious of the outcome of an attack on such a holy place. However the monks employed a watchman on the Snook as a further precaution. The island may well have escaped some of the epidemics that ravaged the mainland at this time. The monks only experienced economic disaster through the destruction of their mainland possessions by the border raiders.

In the fifteenth century there was a market on the island and the laity were occupied as innkeepers,farmers and fishermen and in 'chamber letting speculations' (Raine 1852). The island was also an important staging post for coastal vessels. The Wars of the Roses impinged on the island in 1426 with the landing of French troops and an engagement with the resident Yorkists and finally with the removal of the French by the Earl of Warwick. Foreign mercenaries were used against Scottish raiders from time to time. German troops are recorded at Scremmeston and Fenham, Irish at Bamburgh and Sir Pero Negro's at Haggarston (Tomlinson).

The priory was dissolved in 1537 and thereafter the prosperity of the island gradually declined with a failing ecclesiastical,strategic and economic status. At the start of this period the castle was built on Beblowe Crag,the dolerite on the South-Western edge of the island. From this time on there was a permanent garrison of troops on the island. Its strategic importance was only secondary to Berwick and the island acted as a refuge from the Scots and as a defensible harbour. In 1550 the priory was used as a storehouse. A survey of Norham and Islandshire in 1560/61 indicated the state of the village and its inhabitants. The island was described as 'poor' with especial reference to the fishermen.

All the houses except one had thatched roofs. A list of householders is given in Figure (6). There are 32 names on the document and those whose families are recorded in the registers are marked.

The island became crown property on the death of the last prior. It was then leased to landowners who in turn sub-let to tenants. The latter half of the sixteenth century saw a long legal battle for the crown lease. During this time the church and priory fell into disrepair. The parish subsequent to the death of the last prior was administered by a series of perpetual curates. Whilst the village and church declined in prosperity, the garrison fluctuated in size. In 1559 there was a captain, lieutenant, two gunners, a gunners mate and 20 soldiers. In 1616 there were 16 soldiers whilst in 1637 a captain, a gunner and mate and 9 soldiers are mentioned and in 1639 a captain and 24 men.

There were two epidemics at about this time, probably due to the plague; one in 1606 with an unrecorded number of deaths and one in 1639, in this case the parish registers record the deaths of over 30 soldiers. The church was repaired in the seventeenth century and Thomas Shaftoe, the military governor, gave pews to it in 1646. Reports of wrecking date from this time but they are not well substantiated. However there are reports of disputes amongst the islanders over flotsam (Tomlinson). Brereton in 1635 values the island at £100 per annum with an extra £40 for the warren in the Snook. The annual returns of the rent payers and freeholders indicate a continuity of tenure amongst certain families for many generations.

The mainstay of the seventeenth century economy seems to have been fishing. Documents relating to the eighteenth century enclosure attempts include data to indicate that the 1680's were economically disastrous for the island due to the failure of fishing and the cessation of kelp making. A scheme to drain the Lough also failed at this time. By the

Figure (6)

Names Present in the Survey of Q.Eliz.1 III.(1560/61)

William Aimers	S	Vidua Holbourne	S
Andrew Anderson	S	Laurance Horsley	
William Aymers	S	Richard Hood	S
Andrew Bateensonne		John Johnson	S
George Beard		Richard Johnson	S
Henry Browne	S	Robert Lilburn	S
Thomas Clerke	+ 1580	Michael Metcalf	
Robert Coates	S	Edward Nelson	
James Crawford	S	Oswald Ogle	+ 1597
George Denice	+ 1598	Gawte Prate	
John Dicker		Thomas Short	S
Henry Green		John Short	+ 1594
Phyllis Green		Thomas Short	S
Isabel Harper		Albert Smith	S
William Hewetson	+ 1591	John Smith	S
Isabelle Holbourne	S	Isabel Wenley	
		Robert Wilson	+ 1578

S = A similar surname appears in the mortality register 1578 to 1716

+ = The year of death of a person of the same name until 1600 late seventeenth century the market had ceased to exist whilst the strategic importance of the harbour was temporarily emphasised by the erection of a blockhouse on the Eastern side of the Heugh in 1675. The wills of this period show a wide variation in fortune and status. Weavers,yeomen,widows,freemen and gentlemen bequeathed land,livestock and rights of pasture ranging in value from 11/- to £43. Four wills were proved in 1675 whilst the usual annual quota was less than one.

Prosperity returned to the inhabitants in the early eighteenth century whilst a marked and severe decline was experienced towards the end of the century (see part (c)). In 1728 there were 24 freemen on the island. Freemen were those with freehold houses and rights to pasture cattle,cut grass for thatch,quarry stone and keep fishing boats. There were also stallengers who held fewer rights and did not pay tithes. Bishop Chandler's visitation of 1736 mentions a schoolmaster and records a total of 150 families living on the island including 43 which are Presbyterian and two Roman Catholic. A Durham diocese book of 1793 records nearly the same numbers of Roman Catholics and Presbyterians and the figures are probably noted from this earlier visitation.

Hutchinson writing in 1776 records that the island had 'one farm capable of improvement' with poor,sand blown pasture ,two inns and a few fishermens' cottages. In 1765 four fishing boats were lost in a storm and this probably contributed to the economic decline on the island. These deaths are not found in the parish registers. From various documents relating to the enclosure of the island (1789-91) it is learnt that poor fishing has impoverished the island to the extent that freeholds were let to mainlanders along with rights of pasture, contrary to previous custom. Also the islanders raided the rabbit warren - one of the most valuable assets of the crown lessee - and would not pay harbour dues.

Throughout the eighteenth century customs men were present on the island along with a much attenuated garrison which was finally removed in 1821. The death of a revenue man is noted in 1716 and in 1726 an affray is recorded between the excise and Scottish smugglers.

The implementation of the 1746 Turnpike Act must have resulted in a decline in the importance of news passing through the island by sea and a further lowering of the island's status.

The last decade of the eighteenth century is marked by a return to prosperity. A revenue cutter was stationed on the island with an increased number of revenue men. The old school house was sold and a new one built in 1796 by public subscription. In that year there were 18 pupils and the population had again started to increase. Raine mentions a total island population of 364 in 1797 and the registers record the population in 1798 as 379.

During most of the nineteenth century the prosperity of the island was maintained through the fishing industry. Lobsters were sent to London whilst Lord Tankerville had oyster beds in Holy Island channel. Herring fishing was the main reason for this new prosperity and this continued until the 1870's. In 1826 there were 13 boats and 52 men involved in fishing.

The island seems to have been regarded as a healthy and interesting resort for travellers throughout the nineteenth century. In 1816 the priory ruins were tidied up and by 1859 there were nine inns on the island. The posts across the sands were erected in 1860. In 1865 a proposal to reclaim the sands to the West of the island was rejected on the grounds that it would no longer keep Lindisfarne an island. In the Earl Grey report of 1884 there were about six good lodging houses in operation on the island and the rates charged were twice those of the mainland. The first guide devoted to the island was published at about this time. The other major factor contributing to the prosperity of the community in the nineteenth century was the development of limestone quarrying by a Dundee company. This venture was in decline by the 1870's.

A lifeboat was given to the island by the trustees of the Lord Crewe estates in 1805. The boat was instituted some time later and was manned exclusively by islanders until its recent disbandment. The school prospered with the rest of the community and by the 1850's had over 50 pupils. The church and school were endowed by two charities in the nineteenth century.

The fishermen's cottages seem to have changed little from Elizabethan times up to the nineteenth century. In 1859 the village was described as having untidy houses with thatched roofs and white-washed walls. The 1884 study by the Earl Grey of Northumbrian cottage life indicated that the conditions on the island compared well with the mainland. Apparently by that time all were much improved on the island having back doors and outside lavatories. There were only one or two cottages in the village that were thought unfit for habitation. An average of six to eight people lived in each house.

The twentieth century brought many changes to the island community. In 1948 40% of the islanders were concerned with the tourist trade. This century also saw the consolidation of the historical and archeological position of the island and once more a decline in importance of the fishing industry. Inshore fishing and the shellfish trade became more and more suitable to an island population who also wished to shoot wildfowl and help in the summer with tourism and as part-time carriers and guides. The castle was restored by Luytens in 1902 as a private dwelling and subsequently given to the National Trust. The priory now belongs to the Ministry of Public Buildings and Works.

Many islanders left during the first half of the twentieth century and have been replaced by retired people from the mainland and weekend holiday cottagers. Since the 1920's new bungalows have been built for this group and this has continued until the present day.

The first guide entirely devoted to the island was published in 1884 (Keeling) whilst the twentieth century saw a series of such works. An early example (Halliday 1909) includes a great deal of useful information for the average holiday maker whilst others stress the historical or biological attributes of the island (Graham 1920, Addleshaw 1957,Graham 1958,Tegner 1969). More specialised monographs include one on the priory (Thompson 1949),the Presbyterian church (Paton 1950) and the natural history (Perry 1946). The earliest map of the island is that of Speed printed in 1610 and the earliest chart that of Greenville Collins printed in 1693,the definitive mapping of the island is from the mid-nineteenth century and was published in outline by the Ordnance Survey in 1860; this is shown in Figure (3). The island was not surveyed geologically until 1927 (Carruthers et alia).

Since the last war several new ventures have taken place on the island. The Lindisfarne Mead Company was started in 1965 and employs a few islanders. Two residential hotels supplement the guest houses and now a retreat associated with the church adds to the diversity of visitors.

The school now has one teacher and about ten pupils. Electricity was installed in 1958 and mains sewage in 1961. Water was pumped manually until 1955 and in 1959 the causeway was built and subsequently a metalled road linking the village with the mainland. This has made access to the island easier to outsiders and the tourist boom dates from this time (1959-1965). Nowadays the island is used as a site for fieldwork trips for students of geography (Galliers 1970),botany, zoology and archeology whilst an increasing number of non-islanders use the island as a holiday resort (Nicholson 1969) and others use it for fishing and wildfowling. There is also a holiday home on the island for town children. The amenities include,in addition to those mentioned above,four public houses,several shops,a post office,the castle and priory ruins which are open to the public and a free car park.

The islanders' life is delimited by their occupation. Some of those engaged in the seasonal tourist trade tend to leave the island in winter and stay with relatives,others help with the winter inshore fishing trade. The major outdoor recreations are wildfowling and beachcombing while others study natural history or help with the part time coast watch. Many now drive to Berwick or Newcastle at the weekends and some are employed on the mainland during the week. The vicar,district nurse,a publican,the management of the mead works,the postmistress,the ministry guide and the schoolmistress are all people not born on the island. On the other hand the water company employee, the council workman,the two farmers,all the fishermen and ex-lifeboatmen and the ex-full-time coastguard and the castle guide are all either born on the island or have close kin-ties with other islanders.

The island and its present inhabitants are now undergoing the final phase of transition in economy and personal outlook which started at least a hundred years ago. Fewer islanders are leaving and others who have left are returning. Council houses have been built for island couples. It now seems likely that through tourism many of the island inhabitants will become as prosperous as their ancestors were in the middle of the last century.

Collation

Part (a) summarises the history of the Holy Island population up to the present day. The points which are highlighted and which will be relevant later are the geographical isolation of the population, the fact that there was little reproductive isolation and that there have been marked fluctuations in the size of the population. The population has been associated with specific industries since the dissolution of the monasteries and economic changes in these have been reflected in the size of the island community. The present day inhabitants have experienced a decline in the fishing industry and a marked and recent increase in the importance of tourism.

Part (b)

Methods Used in the Demographic Analysis

Sources of Demographic Data

1.Verbal information from the living islanders.

2.The parish records from 1578 until 1969. These are available on microfilm and two separate transcripts exist.

3.The census returns for Northumberland and Durham from 1801 until 1961. In addition the enumerators' returns for the census years 1841,1851,1861 and 1871 have been studied.

4.Some extra marriages were found in Somerset House,civil registration section.

5.Family trees exist for some island families and where additional information was available this is incorporated.

Methods of Analysis

Each baptismal entry in the parish registers was carded,the record being made to the pattern of Küchemann (1969). This enabled the construction of nuclear families and with the addition of marriage and death records the formation of tentative family trees. The marriage registers were deficient during the Commonwealth period (especially 1654 to 1655), and after 1780 when 'Scottish marriages' were contracted regularly, some,but not all of these being mentioned in a separate section of the parish registers. Between 1825 and 1855 many people who were producing children on the island had no marriages recorded on the island. Similarly the death registers are missing for two brief periods (5th August 1693 to 13th January 1695 and 20th January 1705 to 11th April 1710). In many instances the death records are difficult to interpret as throughout the history of the island many people had the same names. For this reason the deaths of people with the same name have been alloted to the birth cards in an arbritary way. Private family trees, the additional information from civil registration and the occasional additional piece of information present in the registers have all been taken into account to help with this problem. Nevertheless errors must have been made in the construction of the island family trees. Separate trees were made for each male surname on the island.

The majority of the calculations were made using the nuclear families. These were grouped together and placed into arbitrary divisions depending on the year of birth of the eldest child. These cohorts[*] represent a starting point for groups of families and not the demographic events between two specific dates. The first cohort is from 1578 to 1579 and thereafter they follow decades until cohort 40 (1960-1969). The results of this process of aggregation were recorded on sheets of squared paper alphabetically by the name of the father (or the mother if the father was not known). In the next series of columns come the letters M or F indicating the birth sequence by sex. Then comes a separate section showing the birth or baptismal interval in months and finally to all this was added the maiden name of the mother. An example of a cohort work sheet is given in Figure (7). The next step was to examine these records and to find the offspring in any one cohort who contributed further to the island population by being a parent in a later cohort.

A second series of work sheets was then constructed containing only those families whose offspring appear in a later cohort. An example of such a sheet is given in Figure (8). On these sheets the name of the father, the mother and the sequence of offspring is given in a similar manner to the other sheets. Next is given the names and dates

* For definition see page 4.

Figure (7)

COHORT WORK SHEET No. 21

TOTAL COHORT

1770-79

Name Father	Name Mother	Offspring 1	2	3	4	5	6	7	8	9	Birth-Interval -2	-3	-4	-5	-6	-7	-8	-9
* ALLEN Thos.	* WILSON Raechel	M	M+	F	F	M+	F+	M			30	28	31	29	30	31		
* ALLISON Geo.	* GREY Raechel	M	F	M+	F+	M	F+				26	36	37	30	31			
ANGUS Jas		F																
BATESON Rbt		M																
BROWN Thos.	SIBBIT Mary	M	M	M	M						23	49	38					
BURN Jos.		M	M	M+	M	F					27	34	21	33				
COBB Jos.	* REAVLEY Mary	M																
GRANT Jas.		M																
* GREY Geo.	* WATSON Jane	F	M+	F	F+	M	M+	M	M+		13	18	37	34	38	34	49	
* GREY John		M+																
* JACKSON Will	* WILSON Dorothy	M+	M								24							
* LILBURN Rbt.	* TAYLOR Eliz.	M	M	M+	F	F+	F	M+	F	F+	13	27	30	36	32	51	40	16
* LILBURN Jas.	* WALKER El.	F																
LISLE Ralph		F																
MATHER And.	REDPATH Mgt.	F	M	F	F+	M					24	25	39	40				
MATHER John		F	M								16							
MOFFETT Rbt.		M																
* MORTON Will		M	F+	M	M						22	25	52					
PURVIS And.	REAVLEY Phillis	M+	M	F							22	27						
* SIMPSON John	ELLIOTT Marjory	F	F	F	M	F	M	F			23	33	20	19	24	28		
* WATSON Jas.	BURNETT Jane	M	F	F							49	56						
WHITE Will	* ALLEN Mgt.	F	F	M							34	26						
* WILSON Jas.	GIBSON Eliz.	M+	M	M+	M	M	F	M+	F	F+	26	26	31	11	29	43	36	57
WILSON Thos.	* PATTERSON Isab.	M	M+	F	M	M+	M				37	30	42	43	32			

* Birth mentioned in previous cohorts

Figure (8)

Example of an Extracted Cohort Worksheet (No.22) Unrevised
Showing a Contributory Cohort
1780-1789

Name Father	Name Mother	Offspring	Name & d.o.b.	Next C.C.	Ends/Continues
Hall John		FMMFFFFMFF ++	Geo. 16-11-1783	1800	Ends
			Jane 30- 6-1784	1800	Continues
Patterson R. *	Cromarty J. *	MFMFM +	Jane 9- 1-1791	1810	Ends
Patterson J.	Wilson Eliz.	FF ++	Isabel 3- 3-1785	1790	Continues
			Ann twin	1800	Ends
Sanderson H.	Beadland M.	FMF ++	Ann 6-11-1785	1820	Ends
			William 9- 1-1971	1820	Ends
Smith Rbt.		FF +	Mary 22- 7-1787	1820	Ends
Thompson Ra.	Robertson E.	M +	Ralph 26- 3-1786	1810	Ends
Wallace Henry		M +	Henry 7- 4-1784	1800	Ends
Wilson Ra. *	Patterson Is.	FFMMMMM +	James 16- 4-1786	1830	Ends

* Birth mentioned in previous cohorts

\+ A parent in later cohorts

of birth of the children who appear as parents later on. Next is the cohort in which each child appears as a parent and finally a column which indicates if the children in the present cohort produce contributory offspring in yet further cohorts.

People who marry twice are recorded separately. The deficiences in the data become obvious as the analysis progresses. This is seen especially in the lack of data on wives,the difficulty in finding the correct father for a child when there are several men of the same name reproducing at the same time,the inaccuracies associated with baptismal intervals and the very large sibships due to unrecorded second marriages. Despite these deficiences this method of analysis allows comparisons at different stages in the development of the population from 1578 to the present day.

An examination of the completed and unselected cohorts shows various types of island inhabitants.

1.Those couples and their descendants who are found in three or more cohorts.

2.Those couples and their descendants who are found in one or two cohorts but who have characteristic island forenames and surnames and whose marriages are recorded and/or whose sibships appear to be complete and with appropriate death records.

3.Those couples represented by descendants in only one or two cohorts who have unique or common surnames with no marriage records and incomplete sibships and occasionally some explanation of their presence on the island (for example,a soldier).

4.Those couples and their descendants who although they do not form a continuous pedigree from the records available on the island, do crop up over many years. These people are either landowners or the inhabitants of the chapelries or people with a strong regard for the island who have their offspring baptised there from time to time. They are also the families of Protestant dissenters or Roman Catholics.

At the same time there are various types of married couples found in the cohorts.

A. Two people born on the island or who belong to two families whose ancestors have lived on the island for many years.

B. One person from the category A. and one, usually the woman, whose name and birth place are not known. When the name of such a woman is known she has an unfamiliar surname or no traceable relationship with other contemporary islanders. This is usually assumed to be an exogamous marriage.

C. Two people from this second category. That is both partners were from mainland parishes and usually married elsewhere and have produced some or all of their family on the island. These couples are either travellers or from the armed forces. These are called 'new couples' and an influx may be seen in the early part of the nineteenth century (see parts (e) and (f)).

D. Finally the intermediate marriage category may be found between two people who might belong to group A., but some piece of evidence is missing. These individuals may be the children of islanders who were born when their parents were working for a time elsewhere. The baptismal entries are scattered among other parish books and those of Holy Island.

From the above series of marriages and inhabitants can be extracted three island groups, which whilst being genetically and demographically useful categories can also be easily distinguished in the cohort series, the living population and in the census returns. These groups will also be considered in others parts of this thesis.

Group (a) This is the core island population at any one time. The members of this group have characteristic surnames,many relationships with others in this group and a typical island occupation.

Group (b) This is the group who marry into group (a) and who were born elsewhere. As may be gathered from the discussion above,often the lack of evidence leads to the conclusion that a person belongs to this group. This group is mainly composed of women.

Group (c) This is the group,neither born on the island,nor married to islanders,but who are on the island because of their trade or profession. This group may provide individuals for group (b). Nowadays there are many retired people in this category.

Many people of diverse origins are brought to the island and this has been anticipated in the first part of this thesis. Figure (9) lists some of the major occupational groups found in the third of the above categories. Some of the individuals in Figure (9) lived on the island for many years and others brought up their entire families there. At all times this group could provide the alternative to travelling to the mainland for 'non-island' wives or husbands and to this extent this group would provide marriages that were not strictly endogamous nor exactly exogamous as these terms have been defined earlier. In practise this problem resolves itself since in the vast majority of marriages,it is not possible to segregate the true exogamous from this intermediate type of marriage. Thus all such marriages are assumed to be exogamous. This could be of importance when marriage distance is considered later in this thesis.

The above three groups (a),(b) and (c) are approximations designed to simplify the subsequent analyses. They are also useful in understanding how the structure of the island community can change from time to time.

Figure (9)

Non-Islanders Appearing in the Holy Island Parish Registers

and their Occupation

Occupation	Numbers	Dates (in centuries)
Army and Militia	Numerous	17th to 19th
Revenue Men, Coastguards	Sporadic	19th
Guides	Sporadic	18th and 19th
Foreigners	Rare	17th to 19th
Fishermen	Rare	18th and 19th
Limeworkers	Fairly Common	late 19th
Travellers, Vagrants and Strangers	Common	17th to 19th
Peripatetic Tradesmen and Labourers	Common	17th to 19th
Summer Visitors	Sporadic	19th and 20th

The population on the island is in a dynamic state and has never achieved a constant size because of the fluctuating vital rates of the island population. However the proportions that go to constitute the sub-totals remain fairly constant. There has,for example,been a constant proportion of islanders acting as a core to the community and providing most of the inhabitants of the contributory cohorts. Also there has been a small,but constant,gene flow onto the island either as new couples or group (b) individuals from the mainland or the island short stay community. Very small numbers of the new couples have descendants who remain on the island. In each generation more children are born than contribute to the next generation on the island. In order to bring this about there must be a significant degree of child mortality and emigration from the island. The rate of emigration is usually governed by economic factors. In times of economic crisis the first groups to leave the island are those who have been there the shortest length of time. Mortality and child mortality especially is greatest at times of epidemics. After an economic decline or a severe epidemic the potential population which is present on the island will nearly equal the group that actually does go to constitute the next generation. As well as such major causes of population reduction on the island there was also a smaller and more consistent child mortality rate and emigration rate upon which the larger effects were superimposed from time to time.

Fertility has varied from group to group and in some cases has been very great and the accumulated fertility of a few couples over many generations has been exceptional. Nowadays,as for the past 80 years,nearly all the islanders are related,albeit distantly,whilst the number of cousin marriages has at all times been low. This poses some important problems in the second and third chapters of this thesis.

Collation

Part (b) has introduced the major methods of demographic analysis carried out on the Holy Island population. The aim is to display the dynamic state of the population in a way which will allow useful demographic and genetic analysis. This is effected by studying the fertile population divided into arbitrary units or cohorts. This cohort method demonstrates two interlocking populations : the stable (contributory) group and the transient (non-contributory) group. The cohort technique is a longitudinal one and shows the relationships of these two groups through time. The study of the living population and the census data,on the other hand,displays the population at fixed periods of time and here it is possible to define three segments of the population; groups (a),(b) and (c). These may be compared with the two longitudinal populations; the contributory and non-contributory groups,group (a) apparently being equivalent to the contributory population,group (c) the non-contributory population and group (b) representing the interchange between these two longitudinal populations and also between group (a) and the outside world. It is convenient in this chapter to consider the Holy Island population as a demographic unit in relation to the outside world. Holy Island is not reproductively isolated however as an examination of the marriage data in parts (e) and (g) will show. This part will be referred to in several later parts.

Part (c)

Demographic Trends in the Historical Holy Island Population

Moving Averages

It is possible to represent trends in widely fluctuating numerical series by the use of moving averages. This calculation entails taking the mean of a group of figures in a sequence, say the first five values. This mean is conventionally placed medially in this five year sequence (i.e. near the old third value). The next mean value is found by omitting the first figure in the sequence and adding the sixth; this figure is placed second in the new series and near the fourth in the old. Further manipulation was required to properly show trends amongst the Holy Island results. Here a twenty year moving average was determined and the results displayed in the various tables and diagrams only show every fifth value in the new series.

Baptismal Entries

Figure (10) shows the baptismal entries for every fifth year as a twenty year moving average. They show a rapid rise in the sixteenth and seventeenth centuries to a peak in the middle of the seventeenth century. This is due in part to more efficient registration procedures as well as an increase in the sixe of the breeding population. The baptismal rate remained high until the early eighteenth century when a period of emigration among the younger members of the community produced, in effect, a death rate higher than the baptismal rate and so led to the rapid population decline of the mid-eighteenth century. The prosperity of the nineteenth century is, in part, reflected by the increased number of baptisms at this time. The decline that commences after 1850 is accentuated by the separation of the mainland parts of the parish and the introduction of a Presbyterian church on the island. Some 30% of the present population are Presbyterians.

Figure (10)

Holy Island : baptisms

Mortality Entries

Figure (11) shows the total burial entries for every fifth year as a twenty year moving average .The mortality registers are much fuller than the baptismal or marriage entries because persons of all religious denominations are buried in the churchyard. Also included in these registers are many individuals who have only peripheral association with the island; travellers,soldiers and drowned seamen. The registers are imperfect for a number of years and estimations have been made of the mid-period values for the appropriate periods.

Figure (12) shows the accumulated records of births,marriages and deaths for each ten year period from 1700. This shows the various periods when deaths exceeded births on the island. This occurred as part of the population decline in the 1760's and also in the decline that commenced in the late nineteenth century. This figure also shows the increase in the number of births in the first half of the nineteenth century. Marriage rates bear little relationship to these trends and raise the question which will be discussed later of how representative of the population are the marriage registers.

Figure (13) shows the differences in the moving averages between birth and death entries. The figures give a series of values proportionate to the size of the population changes. The overall figure is in excess (136.90) and thus emphasises the fact that emigration must have occurred throughout the island's history. There are only three periods of negative balance:

1.The mid-years 1660 to 1680 when a series of accidental deaths may have temporarily affected the birth rate.

2.The mid-years 1740 to 1770 during a period of emigration and economic decline.

3.The mid-year 1910 to the present day again due to emigration and an economic decline.

Figure (11)

Holy Island: deaths

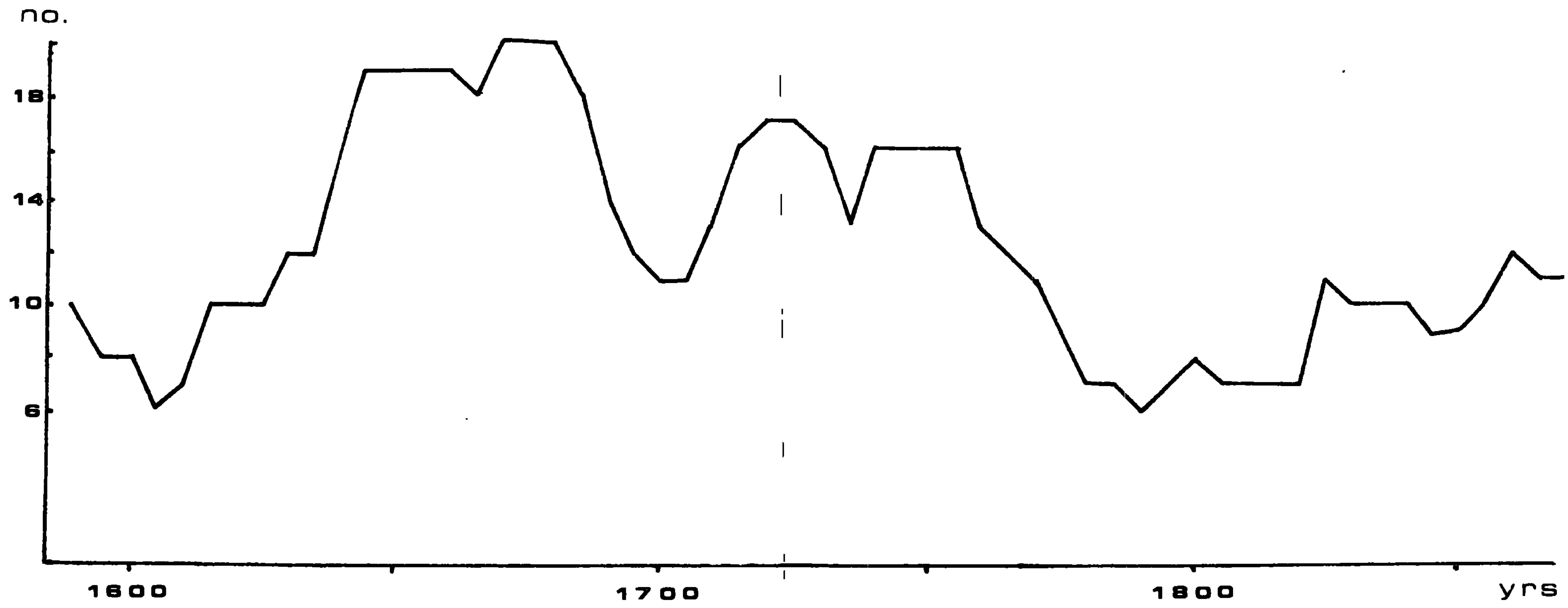


Figure (12)

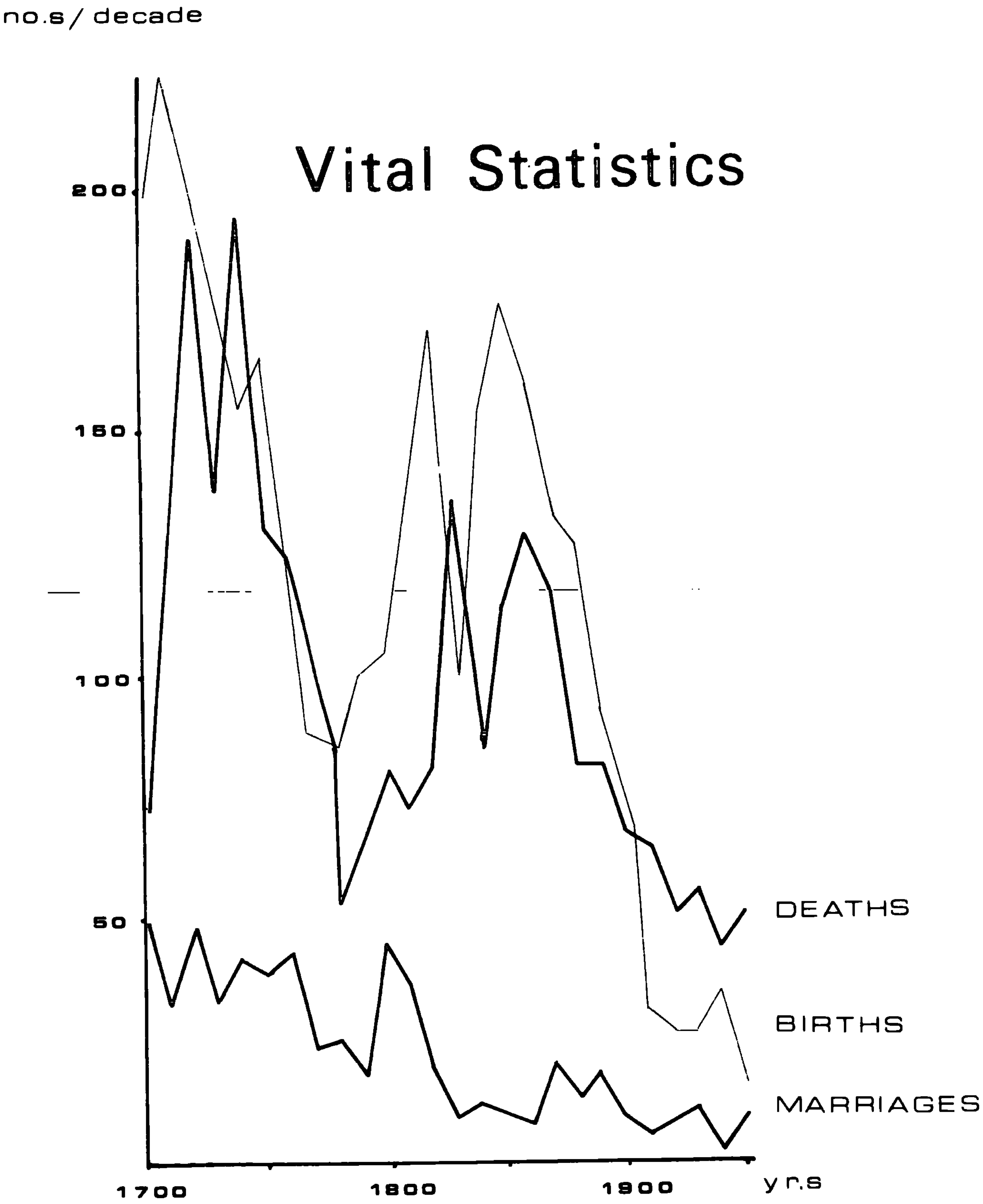

no.s / decade
Vital Statistics
200
150
100
50
DEATHS
BIRTHS
MARRIAGES
1700
1800
1900
yr.s

FIGURE (13)

HOLY ISLAND

EXCESS BAPTISMAL/MORTALITY ENTRIES/5th YEAR

20 YR MOVING AVERAGES

TOTAL POPULATION

D YEAR	EXCESS + DEFICIT -	MID YEAR	EXCESS + DEFICIT -	MID YEAR	EXCESS + DEFICIT -
590	- 1.10	1710	+ 6.70	1830	+ 4.05
595	+ 1.30	1715	+ 5.15	1835	+ 4.05
600	+ 1.55	1720	+ 3.70	1840	+ 3.25
605	+ 1.25	1725	+ 3.65	1845	+ 5.65
610	+ 1.70	1730	+ 2.65	1850	+ 6.60
615	+ 0.35	1738	+ 3.00	1855	+ 5.25
620	+ 0.35	1740	- 0.10	1860	+ 3.95
625	+ 0.95	1745	- 0.25	1865	+ 4.40
630	+ 0.45	1750	- 0.85	1870	+ 3.30
635	+ 3.95	1755	- 1.70	1875	+ 2.95
640	+ 3.60	1760	- 1.10	1880	+ 3.95
645	+ 2.90	1765	- 0.65	1885	+ 3.05
650	+ 3.60	1770	- 0.85	1890	+ 2.75
655	+ 0.05	1775	+ 1.20	1895	+ 1.85
660	- 0.85	1780	+ 1.35	1900	+ 0.85
665	- 0.20	1785	+ 1.50	1905	+ 0.35
670	- 2.55	1790	+ 2.75	1910	- 1.45
675	- 1.05	1795	+ 3.25	1915	- 2.25
680	- 0.10	1800	+ 2.60	1920	- 2.40
685	+ 1.15	1805	+ 5.05	1925	- 3.20
690	+ 3.45	1810	+ 5.65	1930	- 3.25
695	+ 4.75	1815	+ 6.65	1935	- 2.10
700	+ 6.30	1820	+ 7.65	1940	- 1.90
705	+ 8.30	1825	+ 4.25	1945	- 1.95
	TOTAL EXCESS	+ 168.95		1950	- 2.20
	TOTAL DEFICIT	- 32.05			
	OVERALL RESULT	+ 136.90			

Population Size

The census returns are available for the parish of Holy Island from 1801 to the present day. Up until 1900 the returns included the mainland chapelries of Fenham and Goswick whilst Ancroft was listed separately. The population on the island is only known from 1841 to 1871. The parish registers contain an enumeration entered under the year 1797. Figure (14) gives the results available at the time of writing. There is a close overall resemblance between the population size as recorded in the census and the number of recorded births by decades. This is shown in Figure (15). The result for the 1921 census (586) is anomalous as the census took place during the holiday season and includes many non-residents. It seems possible to use the baptismal trends as a guide to the changes in the overall population size that occurred before 1801.

Population Composition

The age profiles for 1841,1851 and 1861 are given in Figure (16). They are for the island population only and for comparative purposes each age group is represented as a percentage of the total population. The actual figures for the male and female populations on the island are given in Figure (17). In all cases except in 1861 and 1951 there are more women than men living on the island. Between 1841 and the present day the average age of the total population has increased, partly by longevity but also as a result of differential migration from the island in early adult life. Today many people who were born on the island return to it on retirement.

Figure (14)

Population Sizes on Holy Island

Year	Island	Island + Mainland ++
1797	364	**
1801	**	601
1811	**	675
1821	**	760
1831	**	836
1841	497	798
1851	553	905
1861	614	935
1871	573	876
1881	**	870
1891	**	804
1901	405	**
1911	359	**
1921	586 *	**
1931	287	**
1951	238	**
1961	190	**

* Census taking during the Easter period

** Not deducible

++ Fenham,Goswick,Broomhouses and Cheswick

Figure (15)

Holy Island ; Censal Numbers & Baptismal Entries

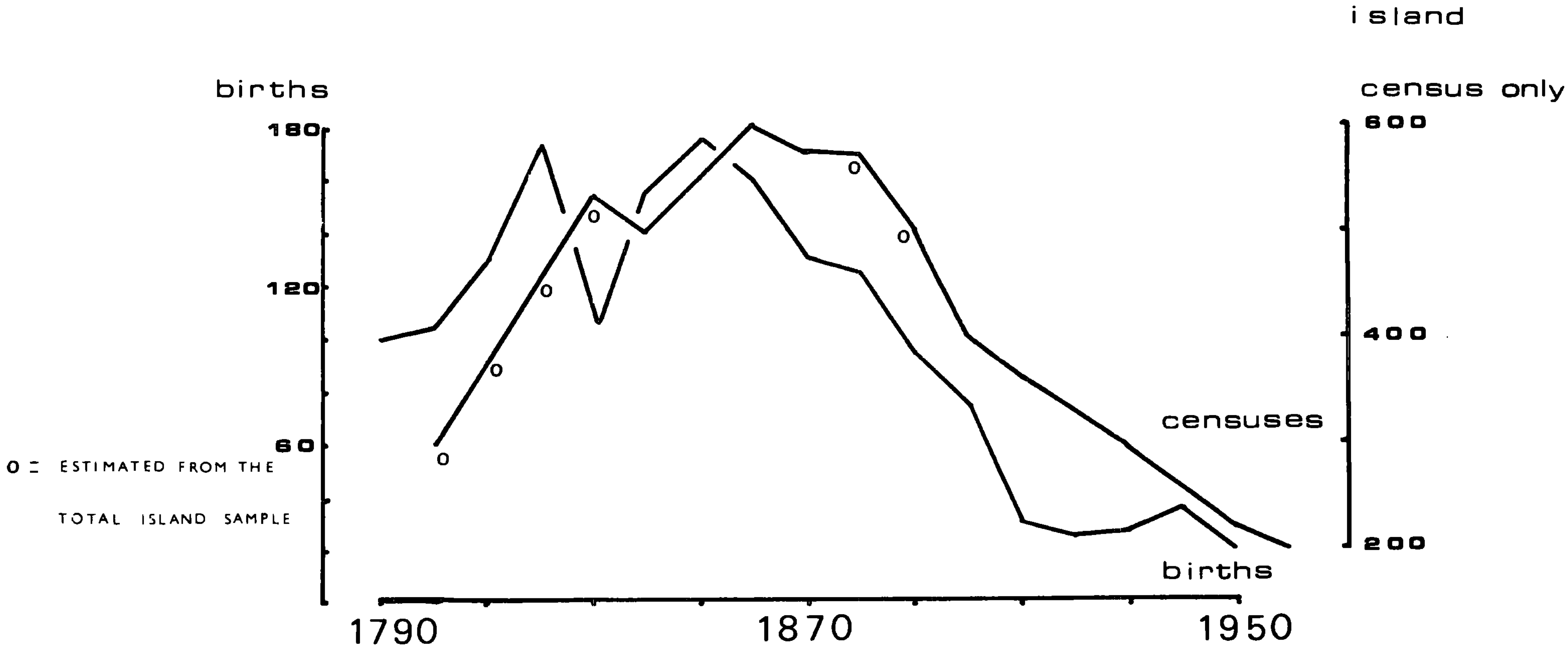


Figure (16)

Holy Island : Age Profiles

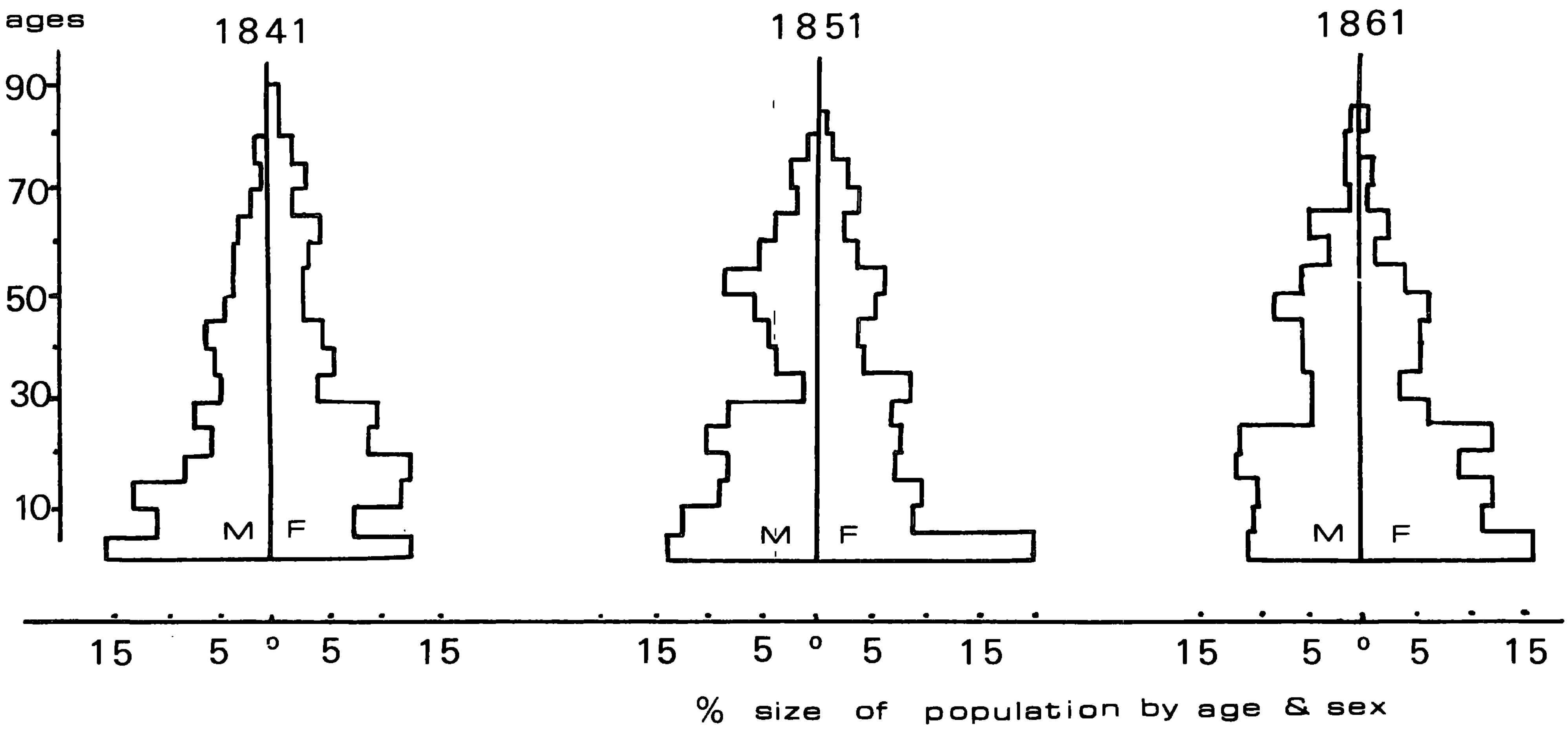


Figure (17)

Numbers of males and females in the Holy Island population

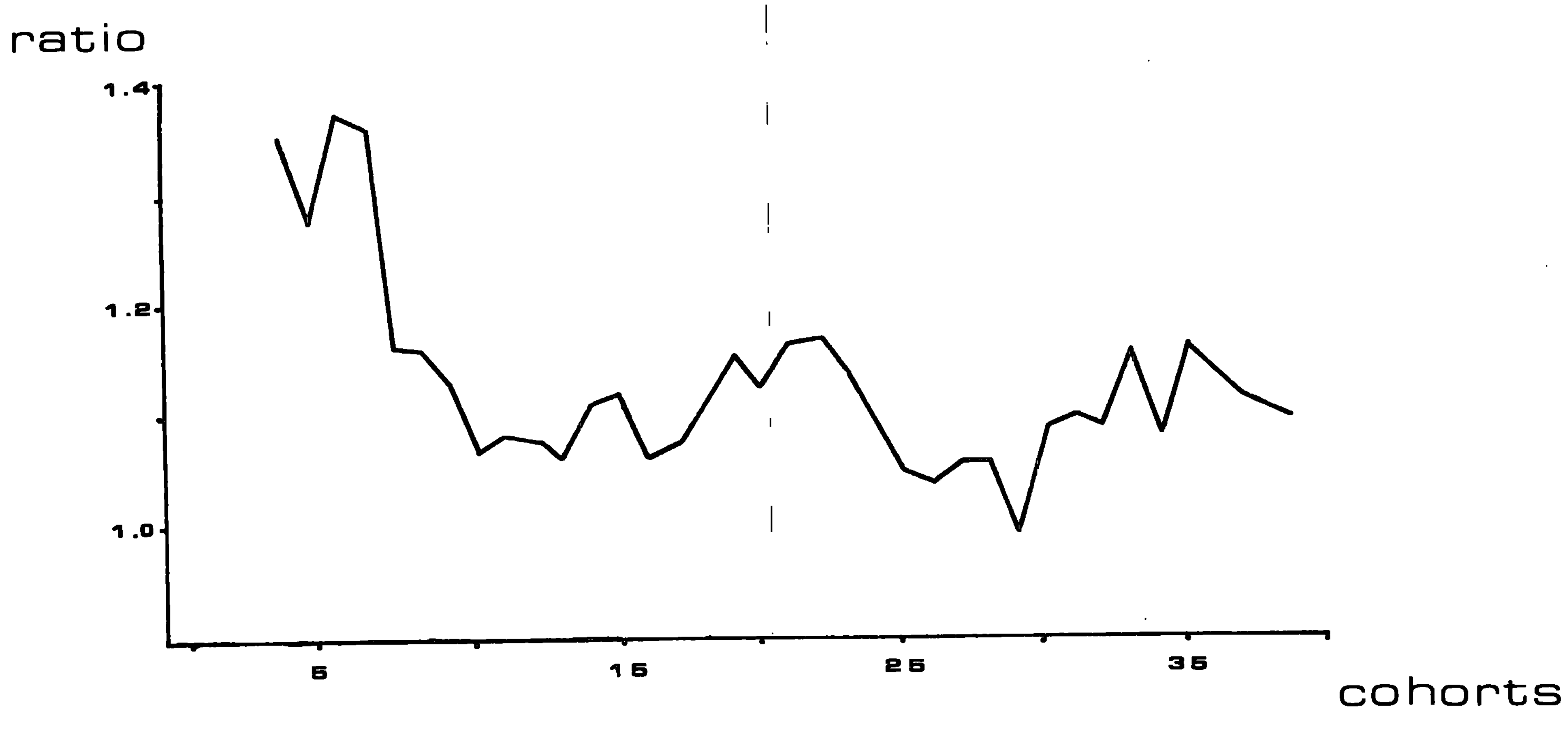
Year	Males	Females
1797 (Registers)	170	194
1841 (Census)	243	254
1851 (Census)	268	285
1861 (Census)	310	304
1911 (Census)	177	182
1931 (Census)	137	150
1951 (Census)	119	119
1961 (Census)	94	96
1970 (Present Study)	77	79

Sex Ratio

The sex ratio at birth by cohorts is given in Figure (18) as a 50 year moving average. The ratio is expressed as the number of males per 100 females. The overall mean of 110.3 is high and due to the high values in early cohorts. This is a facet of lax registration procedures . For the rest of the cohorts,apparently,the sex ratio increases with decreasing populations and vice versa. The contributory population in the cohorts has a much higher sex ratio than the non-contributory population and could account for the excess of males (see part (f)). Figure (19) shows the actual values for the sex ratio in groups of five cohorts. The curved line is an estimation of the trend and shows that the islanders have consistently produced fewer males by proportion with each successive set of cohorts.

Figure (18)

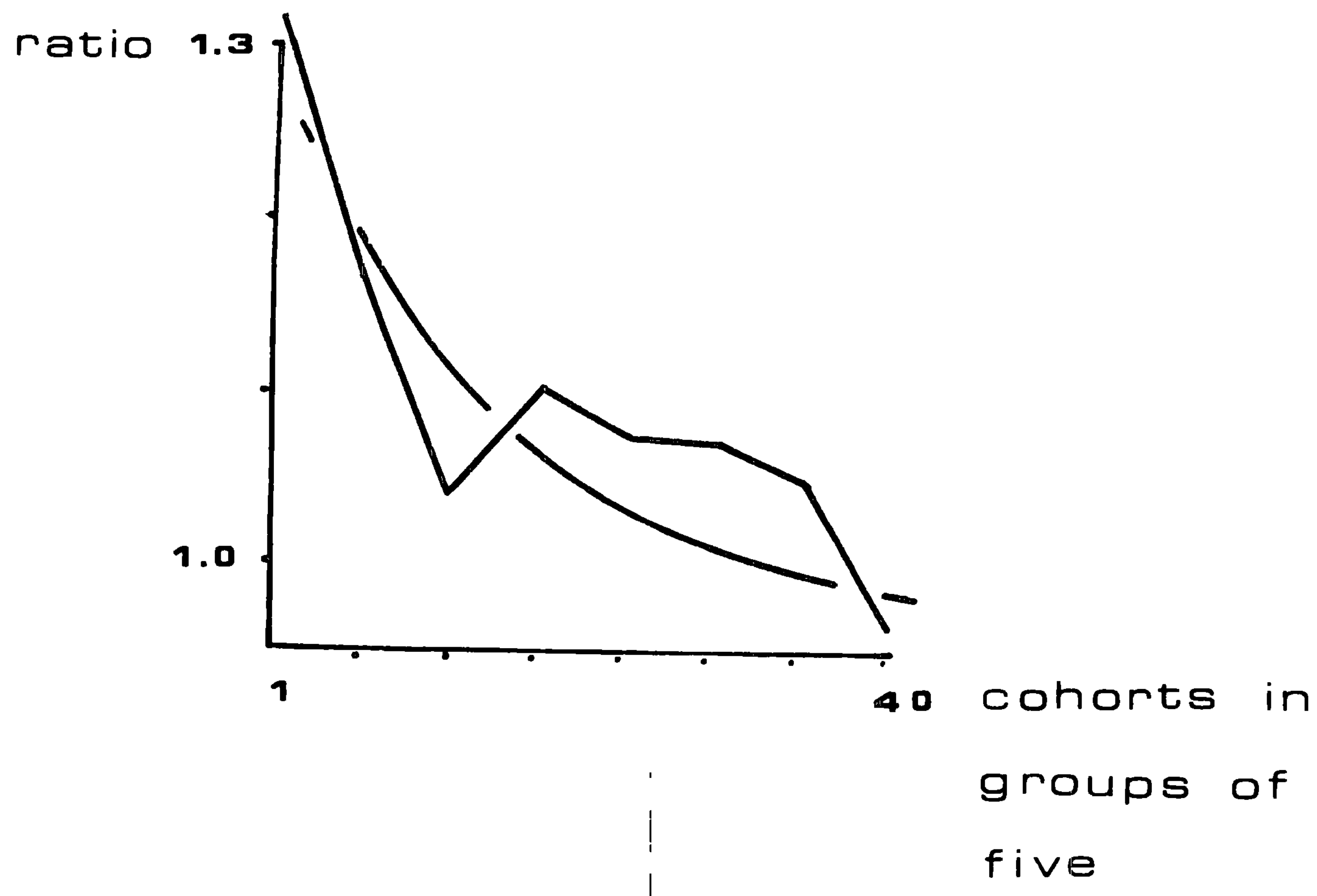
Holy Island : Sex Ratio



(see page 4)

Figure (19)

Holy Island ; Sex Ratio



Sibship Composition

The composition of each family sibship has altered throughout the cohorts. This is shown in Figure (20) which expresses the total number of families of specific sizes for five cohort periods as a percentage of the total. The first group is anomalous in its total composition with a larger proportion of only children and a lower than average number of families with between five and eight children. This is probably due to an inconsistent recording of births with, again,a deficiency of females. Otherwise the proportion of only children gradually increases to the present day with a sudden drop after 1919 in families with five or more children. There is also a similar decrease in the number of families with three or four children. There is a proportionately small number of very large sibships and no apparent trend can be seen.

Birth Interval

The results for average birth intervals are recorded in Figure (21). For the cohorts 6 to 35 the intervals are remarkably consistent whilst the intervals seen in the groupings 1 to 5 and 36 to 40 are longer. There is also a good deal of inconsistency in the younger children of sibships of eight or more. The latter fact is probably due to the smaller sample sizes. The discrepancies in the early cohorts are probably due to the inconsistent recording of all births,especially stillbirths and neonatal deaths. The increase in the birth intervals in cohorts 36 to 40 is a feature of the social trends in this country in recent years but it is interesting to note the sharp differentiation between the 31 to 35 group and the latest group. A further breakdown of the results shown below as Figure (22) gives smaller groupings

Figure (20)

Sibship Composition by Cohorts

Cohorts	Total Number of Children in Family 1	2	3	4	5	6	7	8	9	10	11	12	13
1 - 5	50.7	16.4	11.9	10.0	3.9	3.5	2.6	1.0					
6 -10	39.2	13.7	16.6	9.2	7.0	6.4	4.1	1.6	1.6	0.3	0.3		
11-15	41.3	14.8	10.2	7.0	7.3	5.1	5.4	4.8	1.6	0.6	1.3	0.3	0.3
16-20	41.7	15.8	11.7	7.5	7.4	5.3	4.5	4.9	0.4	0.4	0.4		
21-25	45.1	13.0	8.7	9.2	5.4	4.9	6.0	3.3	2.7	1.1	0	0	0.6
26-30	50.6	13.2	8.7	4.2	6.4	3.8	2.5	4.2	4.5	1.1	0.4	0	0.4
31-35	53.2	11.5	9.0	5.4	7.2	4.5	4.5	3.2	0.6	0.6	0	0.6	
36-40	54.0	30.6	5.6	5.6	0	4.2							

The Figures are

Percentages/5 cohorts

FIGURE (21).

HOLY ISLAND

BIRTH INTERVALS AVERAGED BY FIVE COHORT DECADES : RESULTS FROM BAPTISMAL ENTRIES

COHORT	BIRTH INTERVALS (in months)											
	1 - 2*	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13
1 - 5	45.1	45.9	41.2	35.1	42.9	34.4						
6 - 10	28.4	32.5	32.3	34.5	37.7	31.9	24.3	33.9	30.8			
11 - 15	28.3	29.8	30.3	31.9	27.5	32.4	30.1	26.0	25.6	34.2	19.0	30.0
16 - 20	29.7	29.6	27.3	35.2	34.0	35.1	27.8	46.0	29.0			
21 - 25	26.0	28.1	28.8	30.4	31.3	31.1	38.2	28.1	18.5	37.0	29.0	
26 - 30	28.9	29.3	29.9	34.2	28.2	30.2	31.9	40.4	33.4	46.5	38.0	20.0
31 - 35	27.5	30.4	30.5	34.7	32.7	35.5	48.8	32.0	50.5	30.0	20.0	
36 - 40	40.6	41.8	51.4	24.3	50.3							

* for example, 1-2 means the mean birth interval between the first and second births.

for cohorts 31 to 40. Again there is a clear division between the long and short birth interval which probably commenced with cohort 35 (1910 to 1919).

Figure (22)

Mean Birth Intervals - Holy Island

Birth Intervals	1 to 2	2 to 3	3 to 4
Cohorts			
31 - 32	28.9	31.3	29.2
33 - 34	24.6	26.0	30.3
35 - 36	41.1	42.8	53.0
37 - 38	40.3	45.7	53.3
39 - 40	28.8	-	-

The intervals are given in months.

Birth Season

Figure (23) indicates the birth months of the individuals as recorded on the baptismal registers. The month of birth rather than baptism is used where it is recorded. Birth months are given consistently after 1798 and sporadically prior to that. Most baptisms seem to have occurred within a few days of birth and it is thought that there would be little difference in the totals recorded by both methods. The results indicate overall a dip in the summer months with a peak in March and a higher one in the winter months. The groups of five cohorts vary slightly but with no apparent trend.

Figure (23)

Season of Birth by Cohorts

Numbers in Baptismal Registers for each month commencing with January

Cohorts	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1 - 5	35	41	52	32	35	37	27	37	33	33	46	42	450
6 -10	90	77	101	72	81	60	57	63	71	86	79	75	912
11-15	99	86	90	101	74	69	72	74	83	73	74	96	991
16-20	47	59	67	69	90	51	52	68	56	84	56	72	771
21-25	60	41	58	54	45	48	45	54	30	39	39	40	553
26-30	57	57	68	85	61	68	76	56	66	53	55	58	760
31-35	27	31	49	26	38	44	32	25	27	38	41	32	410
36-40	9	3	18	11	6	10	6	9	9	10	5	6	102
Total	424	395	503	450	430	387	367	386	375	416	395	421	4949

Percentage proportions for each month

1 - 5	7.7	9.4	11.6	7.1	7.7	8.2	6.0	8.2	7.3	7.3	10.2	9.3
6 -10	9.8	8.4	11.1	7.9	8.9	6.6	6.3	6.9	7.8	9.4	8.7	8.2
11-15	10.0	8.7	9.0	10.0	7.5	7.0	7.3	7.5	8.4	7.4	7.5	9.7
16-20	6.1	7.7	8.7	8.9	11.7	6.6	6.7	8.8	7.3	10.9	7.3	9.3
21-25	10.8	7.4	10.5	9.8	8.1	8.7	8.1	9.8	5.4	7.1	7.1	7.2
26-30	7.5	7.5	8.9	11.2	8.0	8.9	10.0	7.5	8.7	7.0	7.2	7.6
31-35	6.6	7.6	12.0	6.3	9.3	10.7	7.8	6.1	6.6	9.3	10.0	7.7
36-40	8.8	2.9	17.6	10.8	5.9	9.8	5.9	8.8	8.8	9.9	4.9	5.9
Total	8.6	8.0	10.2	9.1	8.7	7.8	7.4	7.8	7.6	8.4	7.9	8.5

Twin Studies

Ascertaining twin pairs from the parish records presents some difficulties. One twin often died and may not have been mentioned in the entries,or if it was mentioned then the sex may not always be recorded. Probably there were many twins who both died and of whom there is no record. Also as neonatal diseases commonly affect twins it is possible they were baptised at different times. All estimates of twinning,therefore,are probably underestimates.

Figure (24) gives the crude results dividing the occurrences into cohorts and recording whether they are of like or unlike sex. The registers record 89 pairs in toto with 49 of like sex. Figure (25) carries the analysis further and gives the frequency of twin births and a crude estimation of mono- and di-zygosity based on halving the number of like pairs and adding the halved value onto the number of unlike sexed twins. This method assumes that all the unlike sexed twins are dizygotic and so are half the liked sexed ones. Whatever the errors involved with this method the results of 1% mono-zygotic and 2.6% di-zygotic are not unusual. Fewer twins contribute to the next generation in the cohort series due to the increased mortality amongst them. Ten twins out of 36 die within the first five years of life from cohorts 1 to 9 (27.8%) whilst the death rate for single births for the same period was 10.1%. During this period five children who were twins were born who later produced further island children (13.6%) whilst 16.1% singly born children contributed to the next generation in the same period.

FIGURE (24)

HOLY ISLAND

TWINS AND TRIPLETS

RECORDED IN THE BAPTISMAL ENTRIES

COHORT	TWIN PAIRS	COHORT	TWIN PAIRS
1	1-U	21	O
2	1-L	22	3-L
3	1-U	23	1-L 2-U
4	1-U	24	O
5	1-L 2-U	25	3-L
6	1-L 2-U	26	1-L 1-U
7	O	27	O
8	3-L 2-U	28	2-L
9	2-L 1-U	29	2-L 3-U
10	2-L 2-U *	30	1-L 1-U
11	6-L 3-U	31	2-L 4-U
12	4-L 4-U	32	O
13	3-L 1-U	33	1-U
14	4-L 4-U	34	O
15	1-L 2-U	35	O
16	1-L 1-U	36	O
17	1-L 1-U	37	1-U
18	O	38	O
19	2-L	39	O
20	2-L	TOTAL	49-L 40-U

U = Unlike Pairs

L = Like Pairs

* 1 set Triplems (Rbt. Dodds & Mgt. Bell) FMM

Figure (25)

An Estimation of Twin Types

Cohort	Total No. Children (a)	Total No. Couples (b)	Like Pairs Twins (c)	Unlike Pairs Twins (d)	Total Pairs (e)	% Total *	Estimated MZ Pairs No.	Estimated MZ Pairs %	Estimated DZ Pairs No.	Estimated DZ Pairs %
1 - 4	345	158	1	3	4	2.3	½	0.3	3½	2.0
5 - 8	680	223	5	6	11	3.2	2½	0.7	8½	2.5
9 -12	738	253	14	10	24	6.5	7	1.9	17	4.6
13-16	808	260	9	8	17	4.2	4½	1.1	12½	3.1
17-20	580	201	5	1	6	2.1	2½	0.9	3½	1.2
21-24	391	133	4	2	6	3.0	2	1.0	4	2.0
25-28	636	197	6	1	7	2.2	3	0.9	4	1.3
29-32	523	206	5	8	13	5.0	2½	1.0	10½	4.0
33-36	198	84	0	1	1	1.0	0		1	1.0
37-39	64	42	0	1	1	3.1	0		1	3.1
Total **	4963	1757	49	41	90	3.6	24½	1.0	65½	2.6

* Percentage of children in column (a) who are twins.

** Excluding results from the last cohort.

Accidental and Epidemic Deaths

There are many accidental and epidemic deaths in the Holy Island registers. The major epidemics which killed all groups on the island are recorded in Figure (26).

Figure (26)

Holy Island : Epidemics Showing an Increased Mortality

Deduced from the Parish Registers

Year	Months	Description
1606	October/November	'Diverse this month and next ensuing buried in the visitation'
1639	May/June	Unknown cause - over 30 soldiers and sailors killed
1745	November to January	Unknown cause - many deaths mainly the core group
1812		Scarlet Fever

The deaths of non-islanders are usually the result of such accidents as being 'lost in the tide' whilst crossing the sands. The islanders themselves were commonly drowned but usually at sea. Figure (27) records the majority of such deaths. From 1578 to 1897,228 deaths are recorded as a result of an accident or an epidemic,whilst more deaths are referred to without naming individuals. The majority of these deaths belong to the transient island sub-group but this total includes 34 named group (a) inhabitants who died accidentally. Of these eight do not seem to have had any offspring whilst the remaining 26 had 95 children of whom 25 go on to contribute to the next generation. This gives an average family size of 3.65 and a contributory frequency of 26.3% compared to the total island population (taken from the

FIGURE (27)

ADULTS ONLY AND EXCLUDING SOLDIERS AND SAILORS

YEAR	MODE DEATH	NAME	date of baptism	Marriage	Children	Notes
1663	DROWNED	'one' PATTERSON	? JOHN No date of baptism	?	M+	
1672	DROWNED	Cornelius HEBBURNE	?	*Mgt. Wake	F M F F	
		Richard GRAHAM	?	Francis Brown	M F	
1678	DROWNED	*Thos. JACKSON	24.2.1638	Dorothy North	M F M+	
1679	DROWNED	*Geo. ALLISON	9.7.1631	?	F+ M F+ M+	
		*Jas. JACKSON	14.5.1643	*Rachel Hope	F+ M F	
		*John JACKSON	26.3.1637	*Mary Steel	M F F+ F F	
		*Math. LOCKLEY	13.6.1647	?	F	
1682	DROWNED	Henry HAGGERSTON	No Records of Reproduction			R.C. only death records
1686	DROWNED	*Thos. BROWN	25.11.1649	*Ann Jackson	M+	
1691	DROWNED	*Math.SWINHOE	?	*Isab.Taylor	M+F+ M	
1719	DROWNED	Jas.NICOL	No Records			
		John THOMPSON	26.10.1692	Eliz. Wilson	F M M F+ M M M	Larger Sibship? another J.T.
1722	DROWNED	*Jas. WILSON	?	?	M F	
1726	DROWNED	*Will PATTERSON	29. 8.1683	Ann Balimboro	F F M	
1746	DROWNED	Robt. BROWN	?	?	F	
1764	DROWNED	John WILSON	No Records			Probably Widower in 1730/1740 Cohort
1768	DROWNED	*Ralph JACKSON	?	Jean Jackson	M	
1775	DROWNED	*Will SHELL	9.9.1722	?	M+ M+	

ACCIDENTAL DEATH HOLY ISLAND NATIVES 1578 - 1897

ADULTS ONLY AND EXCLUDING SOLDIERS AND SAILORS

FIGURE (27) contd.

YEAR	MODE DEATH	NAME	date of baptism	Marriage	Children	Notes
1785	SHOT	Will WILSON	No Records of Reproduction			Probably unmarried
1794	DROWNED	Jas.MORTON) John MORTON)	No Records of Reproduction			Probably unmarried
1802	SHOT	*Will WALKER	15.6.1766	Euph.Hamilton	M+ F+	
1814	DROWNED	*Geo. GREY	2.3.1788	Isab. Rankin	M+	
		*Robt. STAMP Jun.	11.2.1777	Christ.Wait	M+ M+ F M M F+ F	
		Thos. MORTON	?	Isab. Patterson	F M+ F M M M M	
		Ralph WILSON Jun.	No Records of Reproduction			Probably unmarried
		Ralph PATTERSON Jun.	" " " "			Probably unmarried
1829	DROWNED	*Math. STAMP	27.10.1800	Sarah Douglas	M F	
* 1833	DROWNED	Geo. WILSON	Age 21 son of Sarah Wilson. No Records of Reproduction			Probably unmarried
1864	DROWNED	*Math. CROMERTY	28.10.1799	?	F	
1875	DROWNED	*Thos ALLEN	12. 6.1805	No Records of Reproduction		Probably unmarried
		*Jas. ALLEN	7. 3.1819	?	F M F+ F	
1884	DROWNED	*Jas. LILBURN	28. 8.1825	Isab. Markwell	F M+ M F F M M M+	
*1843	'BY ACCIDENT'	Rbt. LILBURN				

complete cohorts 1 to 40) which has an average family size of 2.84 and a contributory frequency of 18.3%. In other words, taking the island population as a whole, little difference has been made to the demography of the island by accidental deaths. Figure (27) gives details of this series of deaths.

Surnames

The island seems always to have had a characteristic set of surnames when compared with the mainland. These names, however, are by no means constant and change from time to time. This can lead to difficulties of interpretation, for example the names Brown or Browne appear in nearly every cohort but there are several independent families of this name on the island at differing times. The same is true of the Ord and Douglas families. The cohorts mention 504 different surnames amongst males. Of these 371 (73.6%) are mentioned in one or two cohorts only whilst only 51 (10.1%) span a period of over ten cohorts. These are the names of the core population of the island. The names in the contributory and non-contributory cohorts also differ. There are in fact only five names which span the last 400 years on the island and are still held by members of the core population on the island. More will be said in later sections about surnames and their use in demographic and genetic situations.

Collation

Part (c) has dealt with an aggregative analysis of some aspects of the Holy Island community. The data are taken from the parish registers and the census results. The marked fluctuations mentioned earlier in the social history are displayed numerically in this part with peaks in the seventeenth and nineteenth centuries and troughs in the eighteenth and twentieth centuries.

It is also possible to demonstrate fluctuations in several demographic attributes through time. For example the birth intervals,birth season, family size and sex ratio all show some apparent trends. Little attempt is made to explain these observations; they could be real changes or effects linked to changes in the size of the population.

In addition twin births are analysed and rough estimations are made of zygosity. These estimates have quite a considerable potential error which is discussed in the text. Most of this part,although important in understanding the island population is not referred to in the rest of the thesis. The last brief section,however,introduces the topic of the multidisciplinary use of surnames. This subject will be mentioned later in relation to its possible application to the Holy Island population. Another topic of general relevance to the thesis is the influence of accidental deaths on the fertility of the long stay or core island population. In fact there appears to be no major difference in the family size between those fathers who die accidentally and those who do not. This,however,is a rather suspect comparison which ignores the marked subdivisions of the population mentioned in part (b).

Part (d)

The Census Material from the Mid-Nineteenth Century

This part is included because the enumerators' returns of 1841, 1851,1861 and 1871 offer additional information for fixed periods of time which is complementary to the cohort material. The island inhabitants today may be better contrasted with the census material than with the elongated study of the cohort analysis.

The 1841 census returns only give partial information as to the place of birth (the same county,England,Scotland or Ireland) and approximate ages to the nearest fifth year over the age of fifteen. The later records provide fuller information on origins,age and congenital disability. The total results excluding ships' passengers and vagrants are given in Figure (28).

Figure (28)

Census : Population Sizes for Holy Island Parish

Year	Island	Mainland Chapelries	Total
1841	243 males	150 males	807
	254 females	160 females	
1851	268 males	142 males	860
	285 females	165 females	
1861	310 males	150 males	932
	304 females	168 females	

The results indicate a steady rise in the population on the island with the totals for the mainland chapelries remaining remarkably constant (310,307 and 318). The age profile on the island taken from the enumerators' returns is given in part (c) in Figure (16). The pyramids show an excess of females over males in the group 0 to 5 years. Also the true pyramidal appearance is starting to break up and form patterns more like the modern British population. The structure of the living island population is given in a later section.

The origins of the various populations are shown in Figures (29) and (30). The 65% local inhabitants confirm the view that the island is not demographically isolated. The proportion of immigration from Ireland,Scotland and England is substantial when compared with the results for the mainland where the vast majority of inhabitants are from Northumberland. The tables do not show that the island residents from Northumberland come from a much wider area than the Northumberland residents in the mainland chapelries.

The figures in the 1841 census referring to the 'English' are probably spurious as many of the same individuals in the other censuses are said to come from Holy Island or Northumberland. Also some individuals change their place of birth in the 1861 and 1871 censuses and it is difficult to know which information to accept. On the one hand it can be assumed that each census tends to become better accepted and more accurate with each decade and on the other people tend to become identified with a place after living there for many years and may forget their precise birthplace. Both factors may be operating.

The occupation of the inhabitants during this period of population increase is shown in Figure (31) for the island and Figure (32) for the mainland. On the island,fishing and other crafts connected with the sea constitute the single most important series of occupations, but this is seen to be decreasing by proportion with each census. The regular army present in the castle,then a militia headquarters,

HOLY ISLAND

BIRTH PLACES OF PEOPLE PRESENT IN THE 1841, 1851, 1861 & 1871 CENSUS RETURNS

FIGURE (29)

WHERE BORN	1841	% 1841 Total	1851	% 1851 Total	1861	% 1861 Total	1871	% 1871 Total
HOLY ISLAND	-	-	359	65.0	396	65.1	398	70.6
NORTHUMBERLAND (Mainland only)	-	-	120	21.7	134	22.0	83	14.7
COUNTY **	379	76.3	479	86.8	530	87.2	481	95.3
ENGLAND (excl. Northumberland)	90	18.1	20	3.6	36	5.9	24	4.3
SCOTLAND	23	4.6	40	7.2	32	5.3	42	7.4
IRELAND	5	1.0	12	2.2	10	1.6	14	2.5
OVERSEAS	0	0	*1	0.2	0	0	3	0.5
TOTAL	497		552		608		564	

* Jamaica

** Summation of upper two categories.

Figure (30)

Mainland Birthplaces

Birthplace	1841 Census	%	1851 Census	%	1861 Census	%
Holy Island	-		49	16.3	73	23.2
Northumberland	-		230	76.4	201	64.0
Northumberland plus Holy Island	272	88.0	279	92.7	274	87.2
England excluding Northumberland	6	1.9	1	0.3	4	1.3
Scotland	30	9.8	18	6.0	36	11.5
Ireland	1	0.3	3	1.0	0	
Totals	309		301		314	

Figure (31)

The Occupation of Island Inhabitants

Trade	1841	%	1851	%	1861	%	1871	%
Fishing and allied traders	72	53.7	77	50.0	81	45.3	79	46.2
Army	3	2.2	3	1.9	4	2.2	3	1.8
Farmers and Labourers	29	21.7	30	19.5	24	13.4	27	15.8
Trades and Professions	27	20.2	32	20.8	31	17.3	38	22.2
Limeworkers and Carters	3	2.2	12	7.8	39	21.8	24	14.0
Totals	134		154		179		171	

Figure (32)

Occupations of the Mainland Inhabitants of Holy Island Parish

	1841	%	1851	%	1861	%
Fishermen *	7	10.8	9	9.9	16	15.4
Farmers and allied trades	11	16.9	13	14.3	9	8.7
Agricultural Labourers	42	64.6	62	68.1	65	62.4
Farmers plus Labourers	53	81.5	75	82.4	74	71.1
Tradesmen	5	7.7	5	5.5	6	5.8
Railwaymen	0		2	2.2	8	7.7
Totals	65		91		104	

* Mainly Salmon Fishers

numbered only three or four men. In the first three censuses, farmers and agricultural workers of all types seem to have been on the decline while limeburners and carters increased sharply. Many of the limework labourers in 1861 were from Scotland (about fifteen). This change from traditional occupations is only reflected on the mainland with the increase in numbers of railway workers. Those who call themselves fishermen from the mainland are itinerant salmon fishers and the predominant occupation in the chapelries is agriculture; as it is today.

The surnames of the core population on the island for this census period have certain differences when compared with the living population. Six names are present in the living islanders not present then and fourteen names found in the censuses have since disappeared. In fact two names are gained and two lost in the twenty year intercensal period of 1841 to 1861. Figure (33) summarises these changes and shows that the frequency of 'modern' names gradually increases with each decade. This also emphasises the difficulties involved in the use of 'local' names in any particular study. They tend to change in a gradual way in this community. Figure (34) compares the distribution of names in three of the censuses with the names of the modern community.

The census population presents the community at a moment in time. The cohorts are changing with time and Figure (35) shows how the people mentioned in the 1851 census fit into the cohort series. The living population is found in ten earlier cohorts (see part (g)) whilst this census population is found in seven. This is due to increased longevity and chance that large sibships happen to fall within one particular cohort decade.

Figure (33)

Surnames of the Holy Island Inhabitants

for the Census Periods 1841,1851 and also 1861

	1841	1851	1861
Persons with :-			
Modern Surnames	205 (13 names)	230 (15 names)	278 (15 names)
Names now lost on the island	147 (14 names)	146 (14 names)	138 (12 names)
Total (Island names)	352 (27 names)	376 (29 names)	416 (27 names)
Other names	144	175	195
Total Population	496	551	611
Modern Names as a Proportion of the census names	58.2%	61.2%	66.8%

FIGURE (34)

SURNAME DISTRIBUTION

SURNAME CODE *	1841	TOTAL % 1841	1851	TOTAL % 1851	1861	TOTAL % 1861
V	12	3.4	11	2.9	7	1.7
W	21	6.0	23	6.1	20	4.8
X	34	9.7	32	8.5	42	10.1
Y	8	2.3	6	1.6	8	1.9
F	13	3.7	15	4.0	12	2.9
I	-	0	2	0.5	2	0.5
J	10	2.8	13	3.5	15	3.6
K	14	4.0	19	5.1	27	6.5
M	11	3.1	14	3.7	19	4.6
O	4	1.1	3	0.8	3	0.7
P	14	4.0	17	4.5	19	4.6
Q	15	4.3	19	5.1	25	6.0
R	-	0	8	2.1	8	1.9
T	19	5.4	21	5.6	36	8.7
U	30	8.5	27	7.2	35	8.4
A	9	2.6	14	3.7	11	2.6
B	11	3.1	7	1.9	10	2.4
C	10	2.8	11	2.9	8	1.9
D	14	4.0	8	2.1	10	2.4
E	7	.	8	2.1	12	2.9
1	9	2.6	9	2.4	8	1.9
2	6	1.7	9	2.4	-	0
3	23	6.5	26	6.9	22	5.3
4	2	0.6	1	0.3	-	0
5	7	. .	8	2.1	8	1.9
6	37	.	28	7.	33	7.9
7	8	2.3	7	1.9	4	. . .
8	1	0.3	8	2.1	8	1.9
9	3	0.9	2	0.5	4	. .
TOTALS	352		376		416	
NOT INCLUDED	144		175		195	

* FIGURE (62) Gives the same code for the modern names.

Figure (35)

Holy Island Parish : Cohort Distributions : 1851

Cohorts	Island Inhabitants	Mainland Inhabitants
1790	1	0
1800	10	1
1810	9	1
1820	16	1
1830	10	4
1840	25	0
1850	5	0

Each individual entry in the censuses has been put on record cards. This enables detailed comparisons between censuses and between the census and the parish registers. Figure (36) shows how the 1841 census may be identified from the registers and also what proportion of each group are found in the 1851 census. In fact 306 individuals go on to the 1851 census from 1841 whilst 191 do not. Similar results for the mainland are given in Figure (37). This figure shows that the mainland areas are poorly represented by the Holy Island registers, as is typical of chapelries throughout the country. In addition to this the turnover of population on the mainland is very high indeed. In fact 79.0% of the whole population disappears in ten years,whilst on the island 38.2% of the population had disappeared by the next census. This is probably a migratory effect and the mainland traffic consists primarily of agricultural labourers and their families.

The proportions of individuals present in the censuses and not identified as having been born,married or died on Holy Island varies again with the two parts of the parish.

Figure (36)

The Holy Island Censuses : Island only

The Representation in 1851 of the 1841 census

Those in the 1841 census;

	who are not identified in the registers	unknown baptism but death/ marriage known	known baptism
Who go on to the 1851 census	16 males 26 females	31 males 52 females	104 males 77 females
Who do not go on to the 1851 census	42 males 39 females	9 males 14 females	41 males 46 females
Totals	123	106	268

Figure (37)

The Holy Island Census : Mainland Only

Those in the 1841 census;	who are not identified in the registers	unknown baptisms but death/ marriages known	known baptism	total
who go on to the 1851 census	51	8	6	65
who do not go on to the 1851 census	230	7	8	245
total	281	15	14	310

On the island 24.7% were not identified in this manner while 90.6% were not identified on the mainland. These are mainly group (c) types with a few spouses from group (b). In addition there are a few members (26) of the core population not mentioned in the parish records. These represented a failure rate of 6.5% and half of them had disappeared by the 1851 census. It would be valuable to compare the parish structure of the cases enumerated by Razzell (1972) to see if the turnover was in one specific sector of the community.

The census of 1851 comprises individuals mentioned in 1841 and others who represent natural increase and immigration. These are tabulated in Figure (38).

Figure (38)

Holy Island Censuses : Island Only

Those not represented in 1841,who appear by 1851

	Natural Increase	Immigrants	Visitors	Core Population *
Baptism Known	42 males 52 females			8 males 6 females
Baptism Unknown	3 males 4 females	49 males 44 females	3 males 1 female	
Marriage or Death Record only		9 males 24 females		
Totals	101	126	4	14

* Not in the 1841 census by chance.

Thus the actual immigration over the ten year intercensal period comprises a total of 126 individuals whilst the natural increase during the same period is 101 individuals (seven apparently not born on the island). This gives a high birth rate of approximately 200 per 1000 individuals. Of the results from the 1841 census, 38 had died and 152 had emigrated by 1851 and in addition eight children had died without being recorded in any census by 1851. 190 of the 1841 population had disappeared by the census of 1851 (38.2%) while 227 of the 1851 population were new to the island (41.0%) giving a rate of total increase per year of 3.7 individuals. The true rate is slightly higher than this as there is an excess of females who disappear and have island names (50 out of 71); these are people who have married and whose marriages are not recorded on the island yet some of whom may be on the island in 1851.

This turnover of circa 40% of the island community has probably changed little over the years (see parts (c), (e) and (f)). It primarily affects the short stay residents but not exclusively, as may be seen by the loss of offspring who do not appear in the mortality records. Those people who went to live on the island before the 1851 census and after the 1841 census were taken as 126 individuals; of these, 33 (26.2%) became intergrated into the community to the extent of having marriage or death entries in the registers. Also at this time the natural increase outstrips the natural decrease (38 : 101 deaths : births) whilst the emigration rate is in excess of the immigration rate (152 leave and 126 come).

It is the complex balance between the above four factors, superimposed on the basic island population that decides the structure of the community in the next generation. The situation is in fact more complex than this as the basic island population is capable of being subdivided into at least three demographically distinct groups (see parts (b) and (c)).

Collation

Part (d) has presented details of the Holy Island population taken from the enumerators' returns of 1841,1851,1861 and 1871. The censuses enable the rate of turnover of the island population to be calculated for the mid-nineteenth century. As might be deduced from the social history in part (a) there is a high turnover of the island population. One surprising fact that has emerged,however,is that the island turnover is by no means as great as that on the nearby mainland. Again as might be deduced from part (a) there is a slow change in the types of occupation with each census.

The greatest turnover appears to occur within the non-contributory groups and the fact that there is a slow turnover of surnames from the core population tends to confirm this. The interaction between different segments of the population first mentioned in part (b) may be further explored by comparing the census returns with the parish registers. In 1841 a large number of island inhabitants were not identified through the parish registers (123). This is a measure of the overall rate of turnover and has been shown by Razzell (1972) to vary a great deal throughout the country,perhaps showing for the first time some differential rates of population turnover.

The census material indicates a high turnover rate in the non-contributory or transient population and a very much slower one amongst the core group. This part gives figures for these aspects of the island community and also shows the rate of migration onto the island and natural rates of increase.

Part (e)

The Use of Marriage Data

The problems associated with the use of the marriages of cohort parents discussed here are those of the origin of the marriage partners and whether or not one can learn anything by studying 'endogamy' and 'exogamy'. Also included is the composition of the contributory population and what may be learnt from isonymic marriages. This part may be regarded as one aspect of the study of fertility on the island, the other aspects of this being dealt with in the section on 'children' (part (f)).

Problems of Interpretation

There is a wide variety of problems occurring here. Firstly, the parish registers are very sparse in respect of place name data in the marriage and baptismal entries until 1798. After this time there is a period when the registers, in common with all the other parishes in the Diocese of Durham, were exceptionally detailed. From 1841 to 1871 the registers may also be supplemented by the census material and after 1871 by details from the living islanders.

Prior to 1798 the registers are of little direct use in calculating marriage distances and some other means are adopted.

The island population is not and never has been a self breeding unit and it draws spouses from many miles away. The terms 'endogamy' and 'exogamy' thus have distinct meanings in that they are marriages occurring within and between parishes. It is not possible to define the exact breeding unit of the island, which is a social as well as a geographical phenomenon, so the simple definition of marriages between two people born on the island for endogamy was adopted. Exogamous marriages are those between one person born on the island and one born elsewhere. This simplification creates another difficulty. The movement of individuals that is genetically significant is that which takes place in relation to marriage and the birth of the offspring. All the cohort data refer to marriages in relation to the birth of the first child. However the data found in most marriage registers simply give the places of baptism of the couples. In each case one had to assume when movement occurred ; before or after marriage by the male or female partner. In the majority of cases it may be assumed that such movement would be by the women after the marriage. No such assumption is justified in the case of the Holy Island population. Many of the marriages defined as exogamous were between two people living at the time on the island, and so the movement was prior to marriage and affected the sexes equally.

The differences in the data between the marriage registers and the cohorts reflect the different sub-populations examined. The cohorts represent the breeding population for the island whilst the marriage registers reflect an artificial and fragmented population with only a fraction of the people appearing in it representing the island breeding group. It could be argued that the marriage registers reflect more clearly the true breeding group of which the island is a part. But if all women married at their own parish church then the registers at best should only provide half the true picture. But the definitions above make it clear that the island is to be regarded as the basic unit,and so this cannot hold. The marriage registers omit Presbyterian marriages whilst these/offspring are often included in the birth registers. The marriage registers,like the census data take no account of subsequent fertility. The cohort material eliminates infertile couples and so some of the differences seen between the cohort material and the census results could be accounted for by this fact.

The difficulties associated with the use of isonymic marriages are dealt with under the heading 'isonomy'.

Marriage Distance

This is defined as the distances between the birth places of spouses (see definitions). As has been mentioned in the previous section there are three separate sources of data. The cohorts from 1790 to 1820 include the period when the registers were very complete and represent all the breeding couples of that time. The enumerators' returns for the 1851 and 1861 censuses include all the population living on the island at those times. Many of the couples included in the 1851 census will appear in the 1861 census also. The marriage registers from 1813 to 1958 include,again,people who appear in the census material and also in the cohorts. All the distances are measured from Beal Point,that is the nearest point on the mainland some three miles from the village on Holy Island. All the distances in Northumberland and Berwickshire are measured by the nearest foot route to the centre of the village or the parish,depending on the information given. Many of the places mentioned outside Northumberland are seaports and it is likely that in these cases access was gained to the island by sea. Some of these distances are considerable and it is for this reason that all distances over 100 miles were aggregated. In addition it is difficult to equate land and sea distances meaningfully for the purposes of the definition.

Figure (39) gives the results for marriage distances from these three different sources and Figure (40) shows this diagrammatically with the number of spouses expressed as percentages of the total so that comparisons may be made. There is a general resemblance between

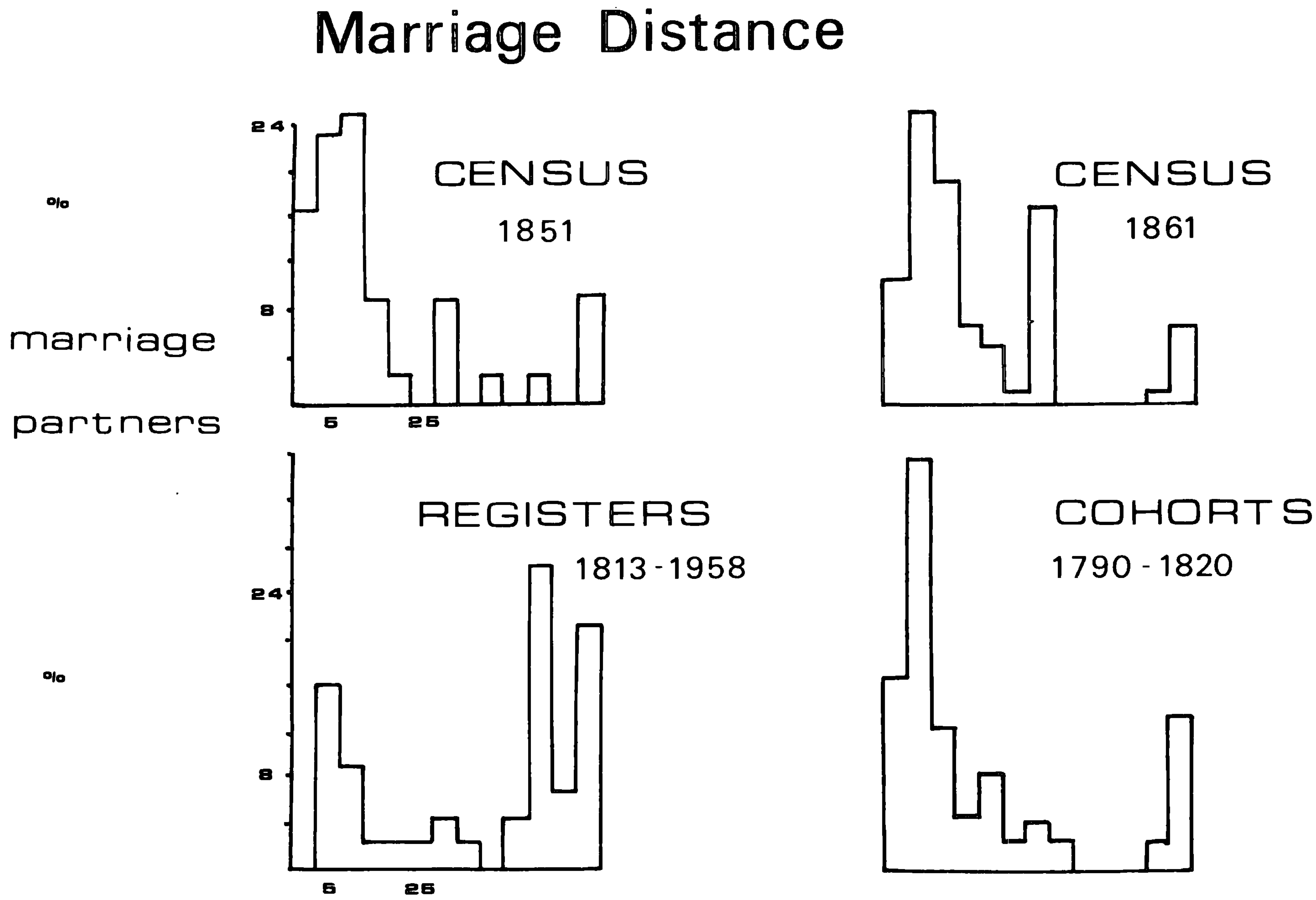
Figure (39)

Marriage Distances on Holy Island

Couples;	Marriage Registers				Total Cohort Decades				1851 Census				1861 Census			
Both from Holy Island		91				33				37				29		
Neither from Holy Island		1				38				23				23		
One Spouse from Holy Island		42				48				43				52		
Distances of other Spouse:	Male	Female	Total	%	Male	Female	Total	%	Male	Female	Total	%	Male	Female	Total	%
0 - 4 miles			0		4	4	8	16.6	2	5	7	16.3	2	4	6	11.6
5 - 9 miles	6	1	7	16.7	1	16	17	35.4	2	8	10	23.3	2	11	13	25.0
10-14 miles	3	1	4	9.5	1	5	6	12.5	3	8	11	25.6	3	7	10	19.2
15-19 miles	1	0	1	2.4	0	2	2	4.2	1	3	4	9.3	2	2	4	7.7
20-24 miles	1	0	1	2.4	2	2	4	8.3	1	0	1	2.3	1	2	3	5.8
25-29 miles	1	0	1	2.4	1	0	1	2.1			0		0	1	1	1.9
30-34 miles	1	1	2	4.8	0	2	2	4.2	2	2	4	9.3	5	5	10	19.2
35-39 miles	1	0	1	2.4	0	1	1	2.1			0				0	
40-44 miles			0				0		0	1	1	2.3			0	
45-49 miles	2	0	2	4.8			0				0				0	
50-54 miles	10	1	11	26.1			0		0	1	1	2.3	0	1	1	1.9
55-59 miles	3	0	3	7.1	1	0	1	2.1			0				0	
100 + miles	9	0	9	21.4	3	3	6	12.5	1	3	4	9.3	1	3	4	7.7
Mean Distance in miles	49.6	24.8	47.3		35.2	19.2	23.5		20.8	21.6	21.4		21.2	21.7	21.6	

The Marriage Registers cover the period 1813 to 1958 with additional Scottish marriages for 1804 to 1822. The cohorts included are those for the years 1790 to 1820.

Figure (40)


Marriage Distance
%
marriage
partners
%
24
8
5
25
CENSUS
1851
CENSUS
1861
24
8
5
25
REGISTERS
1813 - 1958
COHORTS
1790 - 1820

the census and cohort results except for the group from 30 to 34 miles away which has increased from 8% to 16% in the 1851 and 1861 censuses and is less than 4% in the cohort series. This is probably due to an influx of new marriage partners from central Northumberland. The marriage registers are different from the other data. They show that many who marry on the island from a long way away live elsewhere whilst those who marry within 15 miles of the island do so in the mainland parish and then return to the island. Another source of difference between the cohorts and the other material is that the former excludes infertile marriages.

It is not possible to estimate marriage distances directly prior to 1798 but a series of burial entries in the seventeenth century have reasonably good places of origin associated with them. In the fifty years between 1636 and 1686 there were 997 deaths recorded and 223 have associated place names not on Holy Island. The distribution is given in Figure (41). The results indicate a much more local population than is seen in the later marriage and cohort results. This is to be expected from death records. However a lot would depend on the method of location of origin employed by the parish clerk. It is possible he could have mentioned the birth places of individuals or where they lived immediately prior to death. It seems likely that a mixture of the two was used depending on the clerk and the length of residence on the island.

Figure (42) gives the results of the 1861 census marriage distances in relation to the population sizes at the time. All measurements were taken from Beal Point on the mainland. Concentric rings one mile apart were drawn on a map and the population falling within each strip

Figure (41)

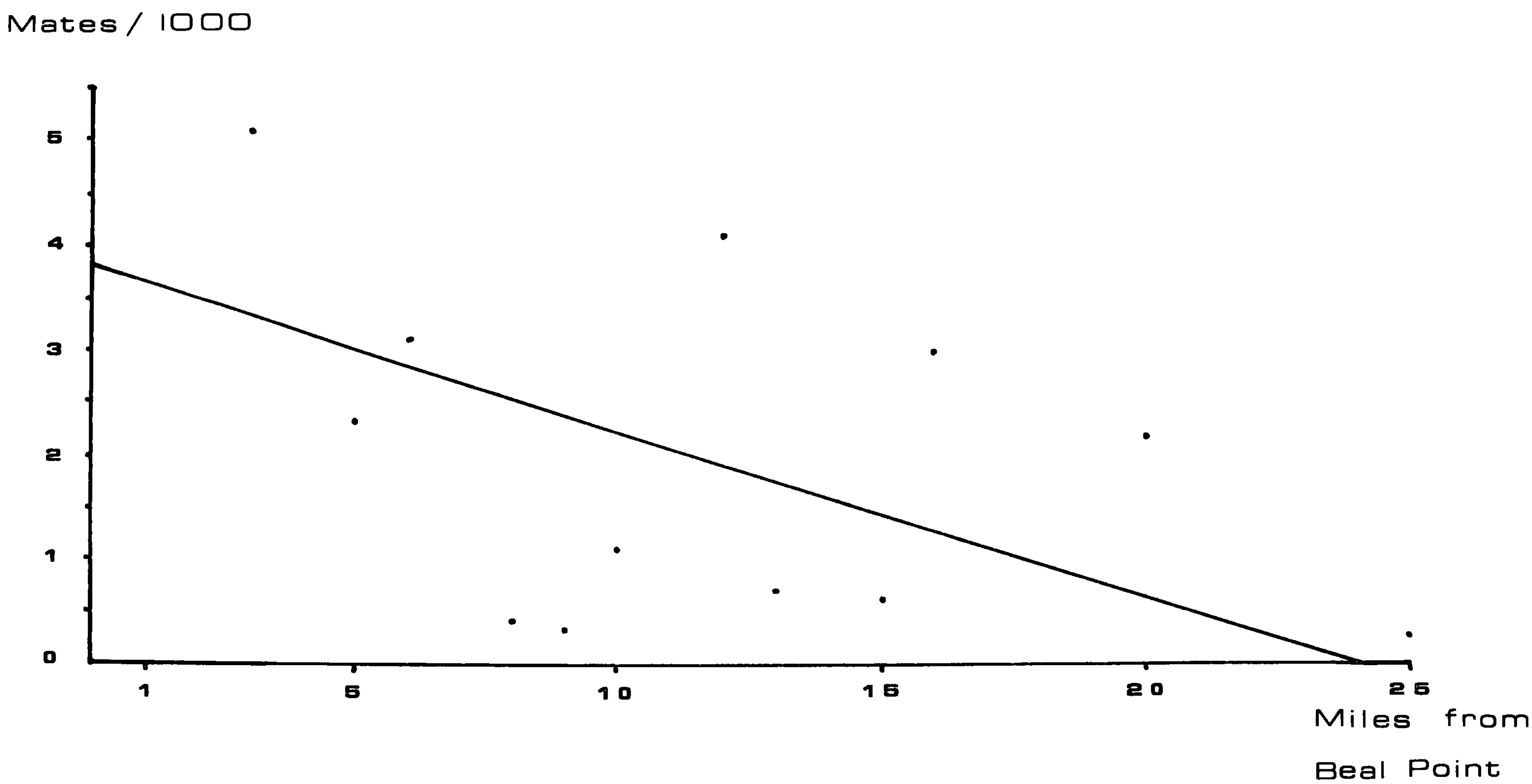
Holy Island Death Registers :

All Entries for the 50 Years 1636-1686

Place Name			
Holy Island	17		
Places 1-1½ miles away	86	)	
2-2½	49	)	Places 0-4 miles away 141
3-4	6	)	
5-9	30		
10-14	5		
15-19	0		
20-24	1		
100 plus	10		
Place name unknown	19		
No place name given	774		
Total	997		

Figure (42)

Holy Island : Marriage Distance 1861



was estimated. This was done up to 25 miles away from the island. The assumption that all distances were travelled on land was made. The results are shown as a scatter which could represent either a curve or a straight line. The only comparable material is from Boyce et alia (1967) and Swedlund (1972). These data at first sight seem to differ from the Holy Island material. The distances are much larger and also the population density is much less when compared with Oxford and Deerfield. The majority of the marriages are within six miles in Oxfordshire and fifteen in Deerfield but go up to 25 miles for Holy Island. Of the three sets of results,the Oxford data may be readily accepted as a curved distribution whilst the other data is much more scattered. More sense is made out of these series when the results are amalgamated as in Figure (43). The different symbols indicate the three different studies. The Deerfield and Oxfordshire results are taken from the published diagrams and may be inaccurate. This seems to indicate that there is a curved distribution and the part of the curve in operation at any place depends upon the population density of that location.

Endogamy and Exogamy

Many of the marriages in the early registers do not produce children and so are not entered into the cohorts. This may be through early death or emigration from the island. These results are shown in Figure (44). The ones that are recorded are the fertile marriages that took place on the island. When the marriage registers have been linked to the cohorts there is a certain proportion of couples where there is no name given for the wife. These results are given in Figure (45).

Figure (43)

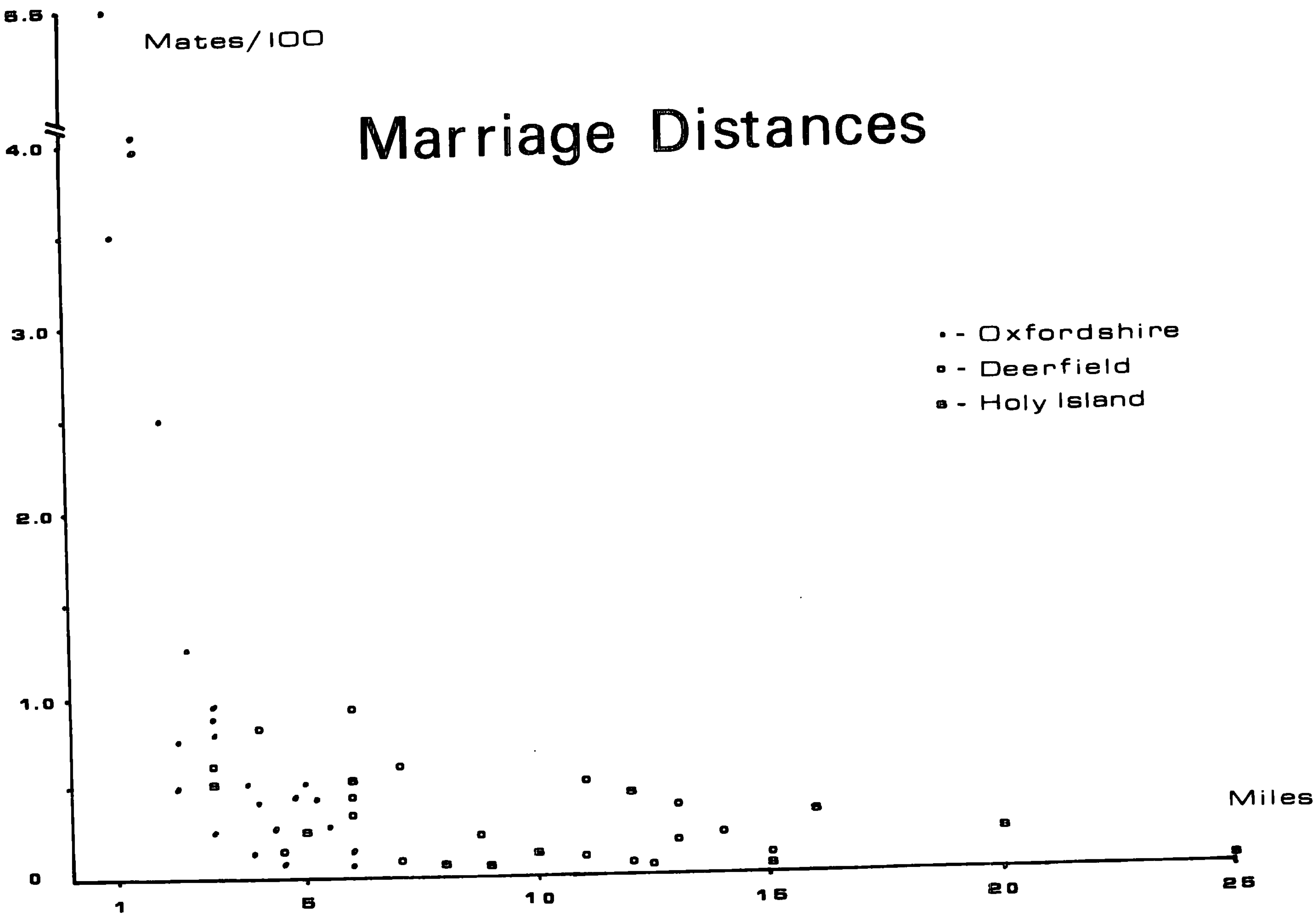

Marriage Distances
Mates/100
Miles
• - Oxfordshire
▫ - Deerfield
▪ - Holy Island
5.5
4.0
3.0
2.0
1.0
0
1
5
10
15
20
25

Figure (44)

Holy Island : The Total Number of Marriages

(From the Marriage Registers) and those not Found in the Cohorts

Cohorts	Years	Total No. Marriages	Marriages Not in Cohorts.	%
1 -10	1578-1669	344	132	38.4
11-20	1670-1769	527	244	46.3
21-30	1770-1869	203	99	48.8
31-40	1870-1969	129	91	70.5
Total		1203	566	47.0

Figure (45)

Holy Island : Blank Maternal Entries from the Cohorts

Cohorts	Number Blanks	% of Total No. of Couples
1 - 5	134	67.0
6 -10	178	56.3
11-15	165	52.7
16-20	131	49.4
21-25	39	21.1
26-30	183	69.1
31-35	81	52.3
36-40	25	35.7
Total	936	52.9

These blank maternal entries could be taken as a measure of exogamy : such marriages could have taken place in the brides' parishes. This probably leads to an over-estimation as certain endogamous marriages are bound to have taken place over the centuries, for example, illegal Presbyterian marriages or Scottish marriages. Figure (45) shows that the number of unknown wives decreases in the first 25 cohorts. This is taken to mean that better registration of marriages is taking place. From cohort 26 to 30 there is an increase in the number of unrecorded marriages which is probably due to Presbyterian marriages. The results for the last few cohorts are abnormal as many couples have their children baptised on the island, whilst having no direct connection with the community.

Figure (46) gives the results of endogamous marriages and other types of marriage on the island. The words 'known' and 'unknown' refer to whether or not the individual is recorded in the birth registers. Column b records the endogamous marriages whilst columns c and d the various types of exogamous marriages. Column e is the population of 'new couples' who belong to the contributory or the non-contributory populations. Endogamy has increased in the last ten cohorts. The earliest cohorts cannot have a high degree of endogamy as defined here through birth records, but cohorts 11 to 30 show a consistent proportion of internal marriages of about 10%. There are more marriages between an unknown woman and a man whose birth is recorded than between a man with no birth record but who marries a woman with a recorded birth; in toto the figures are 24.4% as against 8.1% and these proportions vary little with each cohort. Marriages between fertile 'new couples' are consistently about 55% of the total from cohort 11 onwards.

Figure (47) is taken from Dobson and Roberts (1971) and gives

Figure (46)

Origin of Parents - from Total Cohorts

Cohorts	Total Number Parental Couples	Both Parents Known	% of (a)	Woman Known Man Unknown	% of (a)	Man Known Woman Unknown	% of (a)	Both Unknown	% of (a)
1 - 5	200	2	1.0	4	2.0	11	5.5	183	91.5
6 -10	316	11	3.5	24	7.6	74	23.3	207	65.6
11-15	313	39	12.5	29	9.3	66	21.0	179	57.2
16-20	265	33	12.5	34	12.8	64	24.1	134	50.6
21-25	185	18	9.7	22	11.9	49	26.5	96	51.9
26-30	265	24	9.1	14	5.3	109	41.1	118	44.5
31-35	155	43	27.7	9	5.8	38	24.6	65	41.9
36-40	70	20	28.6	7	10.0	21	30.0	22	31.4
Totals	1769	190	10.7	143	8.1	432	24.4	1004	56.8

Figure (47)

Numbers of Intra- and extra-parochial Marriages (after Dobson and Roberts 1971)

Parish	Period	Total Number of Marriages (a)	Male Indigenous Female Indigenous as a % of (a) (b)	Male not Indigenous Female Indigenous as a % of (a) (c)	Male Indigenous Female not Indigenous as a % of (a) (d)	Male not Indigenous Female not Indigenous as a % (e)
Warkworth	1689-1711	280	248 (88.6)	23 (8.2)	9 (3.2)	0
	1712-1761	658	510 (77.5)	123 (18.7)	25 (3.8)	0
	1762-1811	664	461 (69.4)	170 (25.6)	25 (3.8)	8 (1.2)
Felton	1662-1711	331	260 (78.5)	52 (15.7)	17 (5.1)	2 (0.6)
	1712-1761	557	415 (74.5)	109 (19.6)	32 (5.7)	1 (0.2)
	1762-1812	470	321 (68.3)	132 (28.1)	17 (3.6)	0
Rothbury	1662-1711	672	572 (85.1)	68 (10.1)	27 (4.0)	7 (1.0)
	1712-1761	754	607 (80.5)	118 (15.6)	26 (3.4)	3 (0.4)
	1762-1811	694	522 (75.2)	150 (21.6)	22 (3.2)	0
Alwinton	1719-1761	342	239 (69.9)	75 (21.9)	20 (5.8)	8 (2.3)
	1762-1811	298	263 (66.1)	91 (22.9)	44 (11.1)	0
Charlton	1651-1700		(61)			(39)
on Otmoor	1701-1750		(67)			(33)
	1751-1800		(65)			(35)
Bickenhill	1682-1756		(86)			(14)
Warwickshire	1758-1847		(82)			(18)

some comparable material on 'intra-' and 'extra-parochial' marriages. Column b shows the endogamous marriages and demonstrates consistently higher results when compared with other English parishes. It should be noted, however, that some of this material is from marriage registers and is not extracted from baptismal records. None of the comparative material is in cohort form and represents parishes which have very different histories from Holy Island. Certain cohorts do approximate fairly well to some of the periods in this figure; cohorts 11 to 15 (1670 to 1719), 16 to 20 (1720 to 1769) and 21 to 25 (1770 to 1819).

The number of intra- and extra-parochial marriages varies from those given in the above Figure (46) when the contributory population is extracted. That is the group of children produced on the island who in turn become parents in later cohorts. The results from this contributory population are given in Figure (48). It can be seen that the proportion of endogamous and exogamous marriages are both increased whilst the final column e shows only those couples who introduce offspring into the island population. The number of new couples providing children in the contributory and the non-contributory populations differs in each cohort and is graphed in Figure (49). The new couples going into the contributory group decrease whilst those going into the non-contributory group do not. The number of new males and new females being introduced into the contributory population by exogamous marriages does not vary greatly from cohort to cohort, as in the entire population. Again as in the total population endogamous marriages increase markedly after the 30th cohort. The population was decreasing in size at this time and it is possible that the choice of marriage partners became limited to other long stay residents; as in any population

Figure (48)

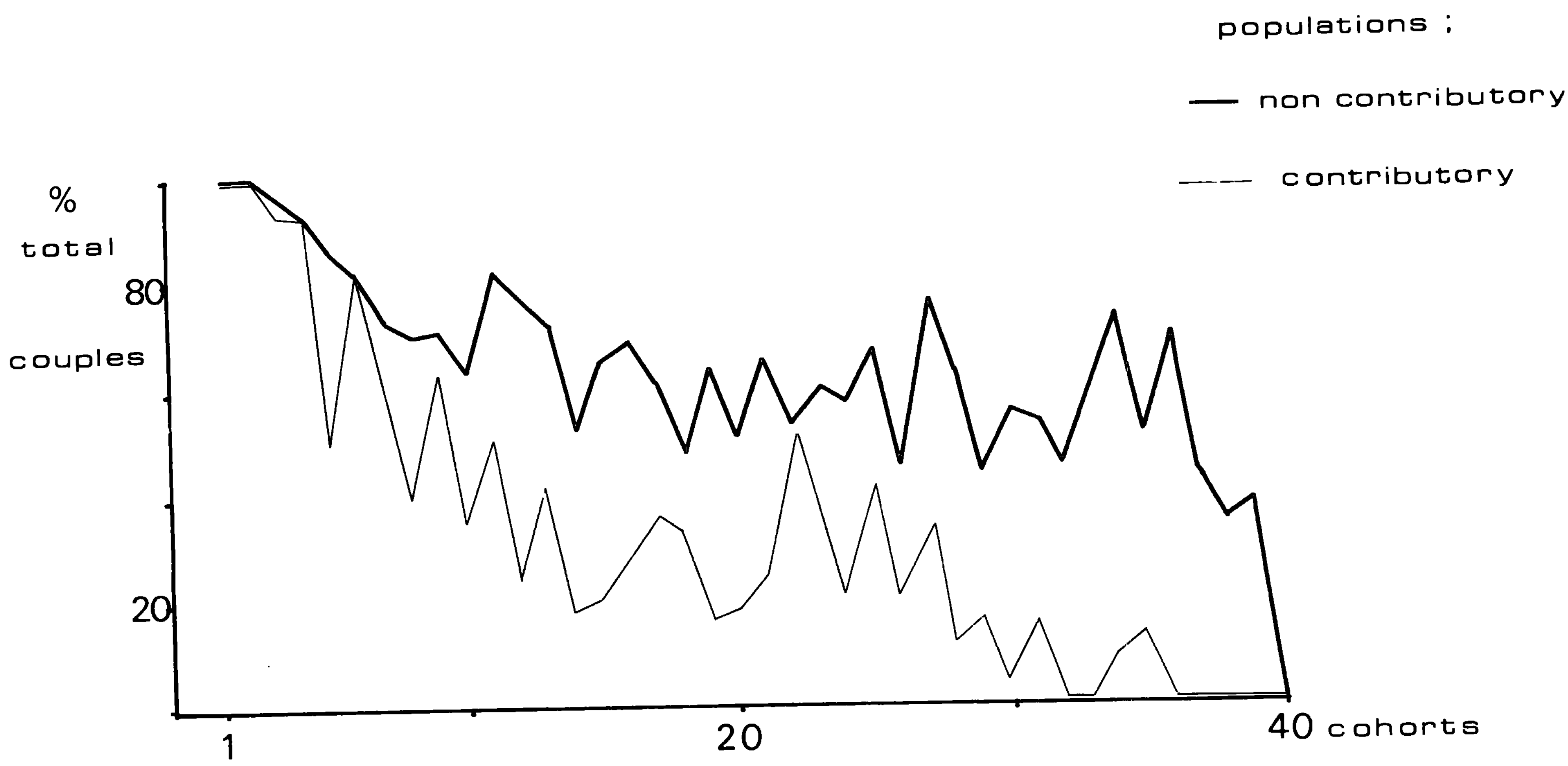
Origin of Parents - from Total Cohorts

Contributory Population

Cohorts	Total Number Parental Couples	Both Parents Known	% of (a)	Woman Known Man Unknown	% of (a)	Man Known Woman Unknown	% of (a)	Both Unknown	%of (a)
1 - 5	55	2	3.6	3	5.5	4	7.3	46	83.6
6 -10	99	9	9.1	9	9.1	28	28.3	53	53.5
11-15	111	34	30.6	9	8.2	34	30.6	34	30.6
16-20	74	19	25.7	6	8.1	29	39.2	20	27.0
21-25	67	14	20.9	6	9.0	24	35.8	23	34.3
26-30	77	15	19.5	3	3.9	47	61.0	12	15.6
31-35	43	24	55.8	4	9.3	11	25.6	4	9.3
36-40	11	6	54.5	1	9.1	4	36.4	0	
Totals	537	123	22.9	41	7.6	181	33.7	192	35.8
Columns	(a)	(b)		(c)		(d)		(e)	

Figure (49)

New Couples



movement those who move first are usually those who have been there the shortest time. This is in part substantiated by the fall in the numbers of new couples entering the island.

Inbreeding

Estimating from the endogamy rate it would seem that up to 1859 the number of inbred individuals would be low. After 1859 it is possible that the level of inbreeding has increased. From the evidence available no first cousin marriages were found amongst the fertile population. There is one mention in the registers of an incestuous relationship producing offspring,in 1635,but the son did not contribute to further generations. The relationships of the living islanders have been fully investigated and this aspect is reported later.

One method of estimating inbreeding is by isonymy. This method has been used by Crow and Mange (1965) and Hussels (1968) to find the inbreeding levels in two populations. The method involves taking all marriages between two people of the same surname and then finding the frequency of these names amongst the breeding population as a whole. The number of isonymic marriages in relation to all marriages is given in Figure (50). This material is from the marriage registers and the 100 year periods are strictly chronological. They show that the overall frequency is low,but without comparable results it is difficult to know how to interpret these figures.

Inbreeding by isonymic analysis has not been calculated. This is because the marriage registers are apparently at variance with the fertile population of the cohorts. In addition the method does not distinguish between fertile and infertile marriages. It is thus

Figure (50)

Holy Island - Isonomic Marriages From the Marriage Registers

Year	Number Isonomic Marriages	Total Number Marriages	%
1578-1677	5	387	1.2
1678-1777	16	507	3.1
1778-1877	2	192	1.0
1878-1957 *	2	95	2.1
Total	25	1181	2.1

* An 80 year period

difficult to know how to obtain the frequencies of isonomic surnames as the cohort population has so many unknown marriage partners amongst it. Also of the 25 isonomic marriages about half do not appear to have any inter-relationship between them at all and of those with demonstrable relationships few are closer than third cousin.

The situation is left, therefore, until a complete analysis of relationships has been done for the total historical populations.

Collation

Part (e) first of all deals with the difficulties encountered in obtaining reliable data from marriage records. The main analysis in this thesis deals with the fertile population and some evidence is presented to suggest that the sources from which marriage data are obtained alter the results. With this in mind the nineteenth century marriage distances are recorded and also compared with data on marriage distances from other sources. From this it is shown how population density affects the apparent migration distances at marriage. As might be expected distances are greater in areas where the population density is low. The nineteenth century marriage distances might also be long due to the social history of the island (see part (a)); the 'outsiders' coming to reside temporarily on the island thus creating a situation the reverse of 'neighbourhood knowledge'. More details of this interaction are given in the report on the censuses (see part (d)) and also in this part. For example, the very low rate of endogamous marriages on the island can really only be explained in terms of a transient or group (c) population as outlined in part (b). As well as the social character of the island, the island's coastal position has also had an influence on the type and origin of marriage partners,many spouses,for example,coming from sea ports in the South of England.

The term 'new couple' is used here after being introduced in part (b). Their appearance may be explained in terms of history in the first part and the hypothesised population subdivisions introduced in the second part of this chapter. New couples may be founders of the core population or simply be a part of the transient population; the two types may only be defined as a result of what happens to their children. If these children marry island inhabitants also born on the island then the original 'new couple' is contributory in terms of the longitudinal core island population.

Unfortunately much of the analysis of marriages can only be done on post-1800 material due to the nature of the records; estimates of endogamy may be made from an earlier date,however,and this is done in this part.

The history of the island and the demographic trends shown in part (c) indicate that inbreeding to any marked degree is unlikely. This is confirmed by the brief analysis included at the end of this part.

Part (f)

The Fertile Population

This part is the complementary half of the demographic study that deals especially with the fertile population and was commenced in part (e). The various types of marriages and the origin of marriage partners are a relatively simple matter when compared with the complexities associated with the analysis of differential fertility.

There are several different possible futures for children produced on the island,in terms of this demographic analysis. Some become parents in later cohorts,others die prior to the production of children, others emigrate and often individuals do a mixture of these such as emigrate,produce children (not found in the records) and return to the island to retire. The fate of the offspring,more than any other factor,delineates the type of island inhabitant in the next generation. In the present study the children are used to define the two separate populations; the contributory and non-contributory groups. The former being,in the main,the long stay,typically named,island inhabitant who has children who become island parents later on. The non-contributory group are those who are not the contributory group; that is,they are a mixed and fragmentary group. Although this group is contrasted on many occas-ions with the contributory population,it is not really a genetic and demographic entity. As defined each group tends to contain the majority of one type of islander : the core population or otherwise,but this is by no means invariably the case. Nevertheless once a couple introduces an offspring into the contributory population it appears that there is a greater probability that some of the offspring will in turn contribute further offspring into this population.

Figure (51) shows the children subdivided in relation to their descendants,it draws the distinction between the total number of offspring of parents who belong to the contributory population (column b),and the actual number of children in each cohort who become parents in a later cohort (column c). In order for a family unit to be included in column b then at least one offspring must be a parent in a later cohort. In addition to this subdivision,many of the children in column c only appear in one further cohort and then the grandchildren of the original couple disappear from the records. Column e records those couples whose descendants go on for more than one further generation. The percentages in columns d and f are of the total number of children produced in the cohorts; both the contributory and non-contributory groups. Thus of the total island births (5023) 18.3% of the total reproduce one generation on the island and 8.9% of the total have descendants of two or more generations reproducing on the island. Columns d and f show that over the decades these proportions have varied little. Changes in population size do not seem to have had any marked effect on the island contribution to the next generation. the same is also true of the entry of new couples or new marriage partners into the community (see part (e)).

The two groups of offspring form different and contrastable populations. Figure (52) shows that the total number of children per parental couple is very different for the two groups,with twice as many children being produced by the contributory as the non-contributory population. This is because the non-contributory group contains many fragmentary families and it is also possible that the larger the family the more likely it is that that family will provide offspring for the contributory group. It has already been shown that

Figure (51)

The Fate of Children

Cohorts	Number Children Produced	Contributory Cohorts No. in toto	Contributory Children	(c) as a % (a)	Contributory Descendants 1+ generation	(e) as a % (a)
	(a)	(b)	(c)	(d)	(e)	(f)
1 - 5	453	188	82	18.1	40	8.8
6 -10	926	455	144	15.6	91	9.8
11-15	972	504	191	19.7	100	10.3
16-20	773	367	114	14.7	61	7.9
21-25	558	330	124	22.2	62	11.1
26-30	783	421	169	21.6	68	8.7
31-35	430	183	79	18.4	27	6.3
36-40	128	37	15	11.7	0	
Totals	5023	2485	918	18.3	449	8.9

Column (b) gives the numbers of all the children born of parents in the contributory cohorts, whilst column (c) numbers only those who are parents in at least one further cohort and column (e) enumerates those children whose descendants are found in ,at least,one additional cohort as well.

Figure (52)

The Production of Children - Contrasting Two Cohort Series

Cohort	Contributory Cohorts Number of Parental Pairs	Number of Children	Children/ Pair	Non-Contributory Cohorts Number of Parental Pairs	Number of Children	Children/ Pair
1- 5	55	188	3.4	145	265	1.8
6-10	99	455	4.6	217	471	2.2
11-15	111	504	4.5	192	468	2.4
16-20	74	367	5.0	191	406	2.1
21-25	67	330	4.9	118	228	1.9
26-30	77	421	5.5	188	362	1.9
31-35	43	183	4.3	112	247	2.2
36-40	11	37	3.4	59	91	1.5
Totals	537	2485	4.6	1222	2538	2.1

the proportions entering the next generation do not vary greatly and if the production of children into later cohorts is due to chance then larger families would be favoured in this respect. Again the trends shown in Figure (52) are reasonably constant throughout the 40 cohorts.

In the 1851 census there were 100 couples on the island with 294 of their offspring. This gives a rather low apparent figure for the family size but the difference is a measure of the mortality and emigration from the island at the time and also in many cases represents partly completed families.

Figure (53) again contrasts the two populations and shows differences in the sex ratio between the children whose children and grandchildren reproduce on the island and the population in the non-contributory cohorts. There is an excess of males in the former group. This is in part due to the fact that the names of males are more easily found than those of married women in later cohorts (as parents), so in this respect the group extracted from the contributory population is an under-estimation of the females who have offspring later on. Also in the earlier cohorts males were more frequently baptised than females. Both these facts give a proportion of 'missing wives' in the cohorts (see part (e)). Figure (54) shows the number of missing spouses in the contributory cohorts. This figure may be contrasted with Figure (45) which gives data for the entire population. The more women identified the nearer the sex ratio is to unity.

Another indication of the randomness of the contributory population is given in Figure (55). Here the birth season of the two populations is given. The non-contributory group has a peak of births in March and the births vary per month from 7.2% to 10.5%. The core population

Figure (53)

Sex of Offspring : by Cohorts

	Contributory Cohorts			Non-Contributory Cohorts		
Cohort	Male	Female	M/F	Male	Female	M/F
1 - 5	55	27	2.04	190	160	1.19
6 -10	95	49	1.94	393	371	1.06
11-15	115	76	1.51	380	397	0.96
16-20	66	49	1.35	337	315	1.07
21-25	83	41	2.02	203	225	0.90
26-30	95	74	1.28	294	289	1.02
31-35	38	39	0.97	171	164	1.04
36-40	9	6	1.50	54	55	0.98
Totals	556	361	1.54	2022	1976	1.02

<u>Figure</u> (55)

<u>Birth Season</u>

The contributory population contrasted with the noncontributory population

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Contributory	73	69	67	67	67	65	67	72	64	56	69	71
%	9.0	8.6	8.3	8.3	8.3	8.1	8.3	8.9	7.9	6.9	8.6	8.8
Non-Contributory	351	326	436	388	363	322	300	314	311	360	326	350
%	8.4	7.9	10.5	9.4	8.8	7.8	7.1	7.6	7.5	8.7	7.9	8.4

Figure (54)

Holy Island - Cohort Analysis

Missing Marriage Partners from the Contributory Population

Cohorts	Number Marriages	Number with a partner missing	% Missing Women
1 - 5	55	26	47.3
6 - 10	99	34	34.3
11- 15	111	28	25.2
16- 20	74	25	33.8
21- 25	67	6	9.0
26- 30	77	46	59.7
31- 35	43	9	20.9
36- 40	11	0	0
Total	537	174	32.4

has no such peak and a range of variation from 6.9% to 9.0% with nine of the months having results of about 8.0%.

A major aspect of the production of children that has not been fully dealt with in this thesis is the death of offspring. Most of these deaths occur early in childhood. Figure (56) shows the mortality within five years of birth during the first nine cohorts. The percentage of deaths to births shows little variation around the total of 10.9. This table also shows that the deaths occur within the larger families and so by inference among the families that go to make up the contributory cohorts. This may be due to the type of inhabitants constituting the non-contributory cohorts. The results are surprisingly low when compared with the rest of childhood as shown in Figure (57). This figure takes the deaths of all young people from four periods in the last four

Figure (56)

Mortality within the First Five Years of Life

Cohort	Total No. Children	Total No. Deaths	Mortality Percentage	Mean Offspring of Families with 1+ deaths	Mean Offspring of other families
1	51	6	11.8	5.0	1.9
2	64	10	15.6	2.7	2.0
3	119	9	7.6	4.3	1.6
4	111	11	9.9	4.4	2.2
5	108	11	10.2	4.3	2.2
6	99	13	13.1	5.0	1.6
7	242	22	9.1	4.6	3.0
8	185	21	11.4	4.3	2.3
9	192	25	13.0	3.8	2.3
Totals	1171	128	10.9	4.3	2.2

The 'other families' refers to those nuclear families with no recorded death in the offspring within five years of the baptism. No distinction is made in the penultimate column between families with one and more than one child death. No groupimg into the apparent subpopulations is made.

Figure (57)

Mortality of People Assumed to be Young from

The Burial Registers

Years	Deaths Quoted as 'son' etc.*	Number Births	Deaths/ 100 births
1634-1658	237	490	48.4
1713-1737	217	508	42.7
1813-1837	79 **	370	21.4
1913-1937	2 **	63	3.2

* See text

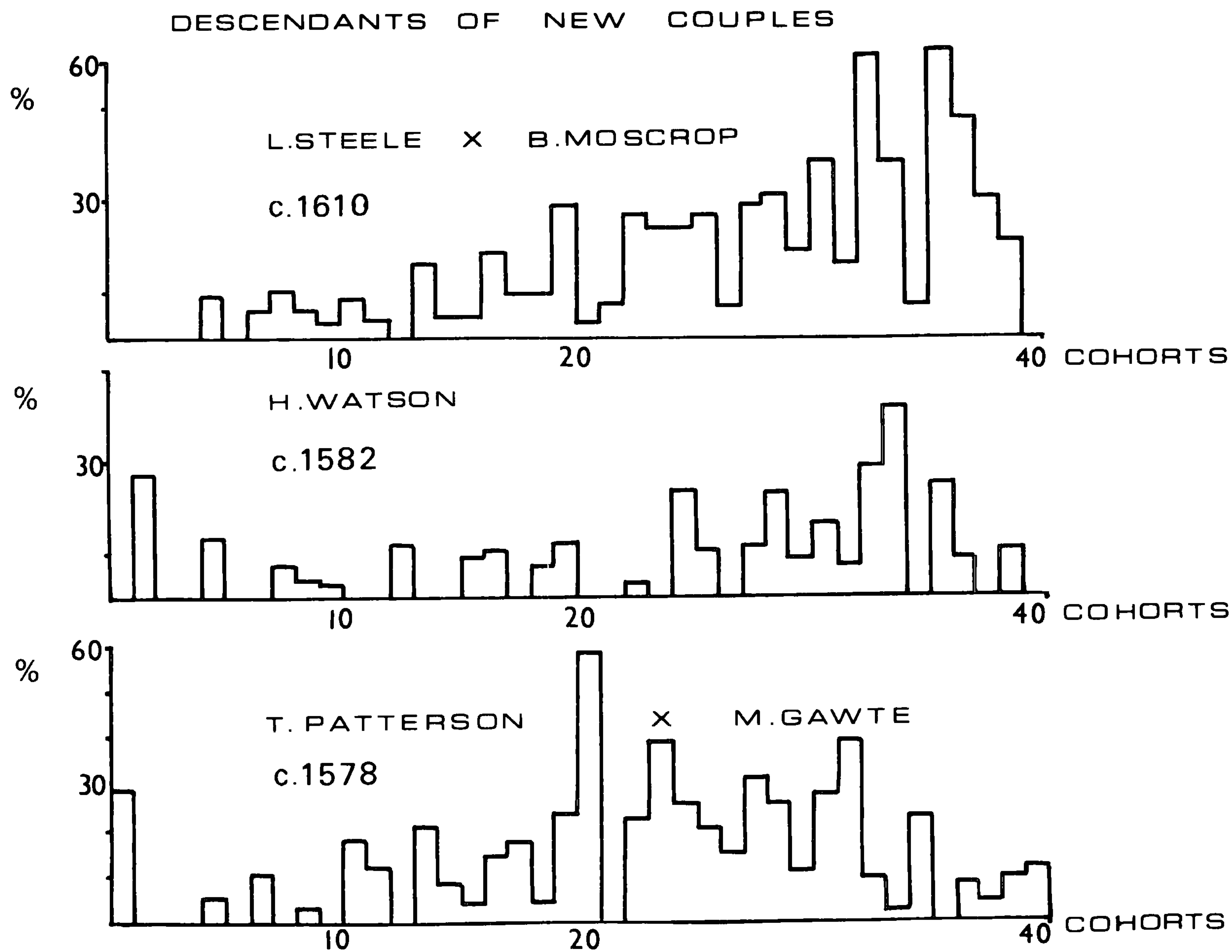
** Ages known and 21 and under

centuries. For the two earlier periods the entries are estimated from deaths marked 'son of' or 'daughter of' and the like. These results show a comparatively high death rate and indicate that the first five years of life have no greatly increased mortality rate when compared with the rest of childhood.

The mortality in relation to the intercensal period 1841 to 1851 has also been calculated. There were ten deaths of children between the two censuses as compared with 148 births (6.8 : 100 births),this fits in well with Figure (57),and shows a sharp drop in deaths among young people in the nineteenth century.

Although there appears to be a constant proportion of children in each cohort who later become parents,there is great variation in the numbers of descendants that any particular ancestral couple have. The section on the contemporary population considers this problem in relation to the minimum number of common ancestors of the living islanders. The problem can also be looked at from the point of view of 'new couples'. Appendix two gives the details of the proportionate contribution of the descendants of all 'new couples' who pass on children to the contributory population. The table indicates the percentage of the total number of children in each cohort that are the direct descendants of the specified couples. The results show great variability with as many as 60% of the children in some cohorts being ancestral to one couple. The number of births included here amount to 3222 and couple 2 has a total of 485 descendants,couple 23 produced 532 and couple 29 gave 335. This is mapped out in a diagrammatic form in Figure (58). This wide range of ancestral genetic contribution would indicate that an element of chance was involved in which ancestors were mainly represented in each generation.

Figure (58)


DESCENDANTS OF NEW COUPLES
%
60
30
L.STEELE X B.MOSCROP
c.1610
10
20
40 COHORTS
%
30
H.WATSON
c.1582
10
20
40 COHORTS
%
60
30
T. PATTERSON X M.GAWTE
c.1578
10
20
40 COHORTS

Collation

Part (f) is an extension of the analysis of the fertile segment of the population started in part (b). The longitudinal population is shown to consist of two demographically distinct segments : the contributory and the non-contributory groups. Whilst living on the island these two groups are shown to have differing numbers of children, differing birth seasons and a varying sex ratio.

As distinct from this it is shown that irrespective of numbers a constant proportion of offspring from one contributory cohort produces the next contributory cohort or generation.

In part (e) the analysis of 'new couples' was introduced ; in this part and in appendix two it is shown that the entire core population may be defined as originating from 96 'new couples'. In addition the differential fertility and in turn contribution of descendants is shown to be remarkably variable ranging from zero to 60% per cohort. This is shown in tabulations in appendix two and diagrammatically for a few couples in this part.

The facts associated with constant apportioning of the contributory longitudinal population suggests that the swings in population size displayed in part (c) are not produced by wide fluctuations in fertility, rather that the changes in population are the result of migrations. As may be inferred from part (a) the economic situation at any one time has a major influence on the population size.

Part (g)

The Contemporary Population

The contemporary population is defined as that existing on the island on the first of January 1970. It consists of three broad groups of people, exactly equivalent to the deceased populations at all stages of the island's history. These groups are (a) the long standing residents, (b) the spouses of residents and (c) the population with little or no association with the island. These divisions cut across the completed cohorts and take no account of a person moving from group (c) to group (b) and whose children would enter group (a). The way the living group fits into the cohort analysis is shown in Figure (59). This table is constructed using the Electoral Register of the autumn of 1969 with additions and ammendments. Those who are not assignable to any cohort belong to group (c), and are called 'none' in Figure (59).

In January 1970 the number of individuals in group (c) was 33; this number needs some clarification, however, as many more come to the island sporadically as weekend cottagers. In fact in January 1970 only 22 of this group could be said to live permanently on the island and it is this group that has been tested for the various population variables in chapters two and three of this thesis.

The age structure of the island population is shown in Figure (60). This diagram only includes the groups (a) and (b). The pattern is the unusual outcome of longevity and differential migration. As there is no one in the age range 46 to 50 and only one person aged from 16 to 20 then the population can be divided into three distinct generations. The younger age group is increasing in size while the older group is decreasing.

Figure (59)

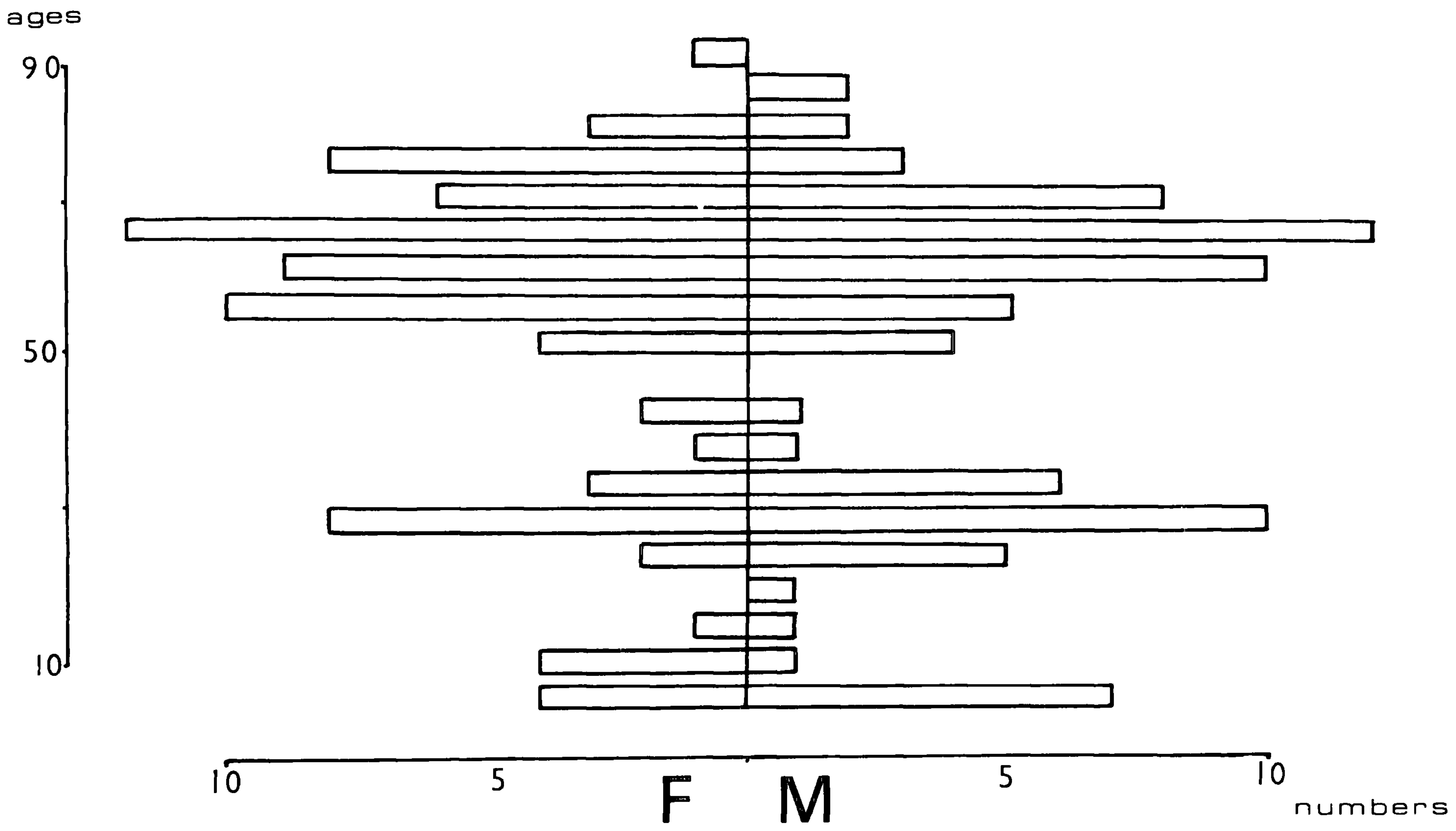
Holy Island

Cohorts to which the Living Islanders are Assigned Taken from the Electoral Register and Verbal Reports

Cohort	Males	Females
1870	2	5
1880	4	4
1890	15	12
1900	16	13
1910	3	4
1920	3	2
1930	3	3
1940	17	5
1950	0	1
1960	8	8
None *	32	47
Total	103	104

* See text : groups (b) and (c) islanders

Age Profile 1.1.1970



Marriage Distance

The entire island population includes 24 marriages in which one partner is from the island and one from elsewhere; 7 marriages have both partners from elsewhere and 26 marriages are between two islanders (six of which have one partner now dead). This accounts for over 100 of the island population, the rest is made up of children and unmarried adults. The origins of the exogamous marriages, where known, are given in Figure (61). The mean marriage distance is 37.3 miles, this is larger than the mean for the 1861 census population which was about 20 miles.

Figure (61)

Holy Island : Origin of Exogamous Marriage Partners

Place	Number
County Durham	5
Newcastle	6
Northumberland	10
South Scotland	3

The Production of Offspring

The total number of children produced by the island population, to date, is 103. This is through 32 parental couples. This gives an average family per couple of 3.2 compared with the total for the cohorts of 2.5. This is an underestimate of the living islanders' fertility as some of the population in the middle generation will be producing more offspring. This is a rough estimate of the fertility of the two older generations. The total number of children produced in relation to the size of the adult community is small (0.7/adult over 18 years of age) indicating that the population will decrease in numbers still further unless the immigration to the island is maintained. The community has never been solely maintained by its birth rate and immigration has been a constant feature of life on the island. Unfortunately recent immigration to the island has been predominantly among older people with children now adult and living elsewhere. These people are not likely to form strong genetic bonds with the community. It is possible the decline in population on the island which has lasted a hundred years is about to cease; the holiday trade and new houses being responsible. It is likely that the population of the future will consist of the three broad groups mentioned above; with a strengthening, once more,of group (a).

Sex Ratio

There are 90 offspring whose sex is known to the author. The sex ratio amongst these children of living islanders is unusual with a predominance of males (60 : 30). This is different from the results obtained from the cohorts and represents a highly selected sample.

Surnames

There is a predominance of certain surnames on the island. These act as useful pseudo-genetic markers and it is thus relevant to note when each appeared on the island. This information is given in Figure (62). Six of the names originated in the sixteenth century,three in the seventeenth century,four in the eighteenth century,five in the nineteenth century and three in the twentieth century. The entire living island community is represented by twenty-one surnames. At

Figure (62)

Holy Island
Surnames amongst the Living Population

Abbreviation of Name *	Number in the Electoral Role	% **	Number and Year of Cohort in which name First appears	
V	7	5.5	3	1590
W	12	9.4	16	1720
X	7	5.5	16	1720
Y	17	13.4	26	1820
Z	11	8.7	34	1900
F	1	0.8	3	1590
G	3	2.4	25	1810
H	2	1.6	7	1630
I	5	3.9	30	1860
J	5	3.9	23	1790
K	5	3.9	3	1590
L	7	5.5	34	1900
M	2	1.6	17	1730
N	4	3.1	36	1920
O	9	7.1	1	1578
P	6	4.7	7	1630
Q	2	1.6	2	1580
R	1	0.8	25	1810
S	2	1.6	31	1870
T	9	7.1	11	1670
U	10	7.9	1	1578

* These are the same as those in Figure (34)

** The % column gives the proportions of the numbers in the previous coloumn.

other times cohorts consisted of a maximum of 58 names and a minimum of 20 names (1650 and 1770).

Of the contemporary names, a search in Guppy (1890) reveals that seven are not to be found at all. Of these, two are probably of Scottish origin and four are local Northumberland names. The names that can be found in Guppy are from Scotland (two), Lincolnshire (one), Yorkshire and Durham (two) and the remaining thirteen are from Northumberland. Five of the names are found in more than eight English counties. The value of this geographical technique will be discussed in the next chapter.

Interrelationships

Part (e) has mentioned the topic of 'inbreeding' and this was considered to be low with perhaps some slight increase in the last 100 years. Nevertheless there are now comparatively few names on the island and many of these have been there a long time. It is thus very probable that interrelationships on the island are common. The interrelationships have been calculated for the living islanders. Appendix one gives details of the N values for the total island population. N values are the number of steps taken to link two individuals via a common ancestor. The co-efficient of relationship used here is the summated value $(\frac{1}{2})^N$. Many pairs of individuals are related by more than one route and so there are more N values than possible pair combinations. All relationships up to a maximum of twelve steps have been included. In all 11,000 interrelationships have been studied and the summated value for this estimate of relationship is 452.9568932 : both pairs were studied as a check and so this is a doubled value. Figure (63) shows the construction of this result. Most of the interrelationships

FIGURE (63)

COEFFICIENT OF RELATIONSHIP FOR TOTAL ISLAND COMMUNITY

VALUES OF N	NUMBER AT EACH N VALUE	COEFF. AT EACH N VALUE	COEFF. χ NUMBER
1	185	0.5000000	92.5
2	342	0.2500000	85.5
3	820	0.1250000	102.5
4	1054	0.0625000	65.875
5	1747	0.0312500	54.59375
6	1803	0.0156250	28.171875
7	1987	0.0078125	15.5234375
8	1509	0.0039062	5.8944558
9	982	0.0019531	1.9179442
10	419	0.0009765	0.4091535
11	140	0.0004882	0.0683480
12	12	0.0002441	0.0029292

TOTAL RELATIONSHIPS χ = 11,000 TOTAL COEFFICIENT SUMMATED R = 452.9568932

TOTAL INDIVIDUALS N = 146 TOTAL POSSIBLE NUMBER OF PAIRS Z = 10,586

COMPENSATED VALUE $r = \frac{\Sigma R}{\chi + Z}$ = .0209838271 = total population are between four and nine steps with the majority of pairs seven steps apart.

It is difficult to know the significance of these results because no other living population has had such a computation made of it. Use is made of these calculations in the other two chapters when the significance of the population variability is considered.

Common Ancestry

At the present stage of analysis the islanders can be shown to have six pairs of common ancestors for all group (a) individuals. These common ancestors are shown in Figure (64). The cohorts mentioned in this figure are the group in which these couples produce their first offspring.

Figure (64)

Holy Island - Common Ancestors of the Living Islanders

Thomas Downey	x	Grace Steele	1610
Will Patterson	x	Marjorie Young	1610
George Grey	x	Mary Day	1610
Thomas Watson	x	Margaret Cairns	1730
Robert Brigham	x	Margaret Watson	1790
Richard Douglas	x	Margaret Dodds	1820

Collation

Part (g) studies the living population just as parts (d),(e) and (f) have studied the historical population. The studies show how the living group fits into the longitudinal scheme presented in part (b). The surname distributions,the age distributions,marriage distances and the origin of spouses are all explicable in terms of the recent history of the island and especially of the major trends in emigration.

A major part of this study of the living islanders is devoted to their relationships with each other and how this has influenced the results in chapters two and three. The part of the analysis presented here and in appendix one shows that there is in fact a considerable degree of interrelationship amongst the living members of the island community. Unfortunately there appears to be no comparative data to contrast with the Holy Island group. For this reason it is not known if the island group is unusual or not. The vast majority of links between pairs of islanders are either of 6 or 7 steps. Part (t) takes the analysis of interrelationships further and attempts to demonstrate their influence on the results of serum cholesterol levels, whilst part (k) does the same for PTC and the Duffy blood group system.

Part (h)

General Discussion

This section is aimed at drawing together all the possible demographic and historical information that could be of use in understanding the structure of the community today. Most of the analyses have been directed towards the fertile population. Some parts of chapter two are directly linked to the study of surnames and the interrelationships on the island. The next chapters will go on to consider further the variation in the living group.

The analysis by cohorts has the disadvantage of not allowing one to study the population fully at many specific points in time, but the introduction of the census material enables such a cross-sectional approach for the mid-nineteenth century. This analysis shows that parameters such as marriage distance,and endogamy studies by cohort analysis,are contrastable with and similar to the census material.

An advantage of the present method of cohort study is that some of the data may be used for self-comparative calculations based on theoretical genetic concepts. This is useful as a great deal of this study has not as yet been compared with other populations,due to the different approaches involved.

The type of genetic concepts that lend themselves to the Holy Island study are those involved with the effective population size (Wright 1969). The index of isolation (Lasker 1960) is an example of this type of calculation. This index is $N_e m$ where N_e is the effective size of the population and m the percentage migration into the community. When this index is less than five then random effects are likely to be in operation. Values of more than five make chance phenomenon progressively less likely until very unlikely over fifty. Migration rates may be calculated by enumerating the 'unknown' spouses marrying into the group (a) population. The effective population is a theoretical one which encompasses a whole breeding unit and which may be estimated from a parental population or from children who later reproduce. Holy Island is not a breeding unit and so the values for N_e are at once under-estimations. Taking the results as are available on the island,it is possible to calculate the effective population size using the parents or the children produced in each cohort. The simplest estimation is that of the contributory population (correction for sibship size does not alter the results very much) and these results give an index of isolation shown in Figure (65). The mean index for 40 cohorts is 9.6,but after cohort 28 the index has been under five. Calculating N_e by using the children may be achieved by finding the number of offspring in the contributory population. Figure (66) shows that these two methods produce very similar results throughout the cohorts. The results in this figure are expressed as a five cohort moving average. Both methods thus produce similar and low indices of isolation.

This example aids in emphasising the other point to be made here. This is that chance effects seem to have played a significant role in the construction of the community. Many opportunities for random effects have been demonstrated in the previous pages. The fluctuation in population size produces a 'bottleneck' effect,for example,with non-specific selection of certain individuals. Systematic

Figure (65)

$N_E M$ (INDEX of ISOLATION)

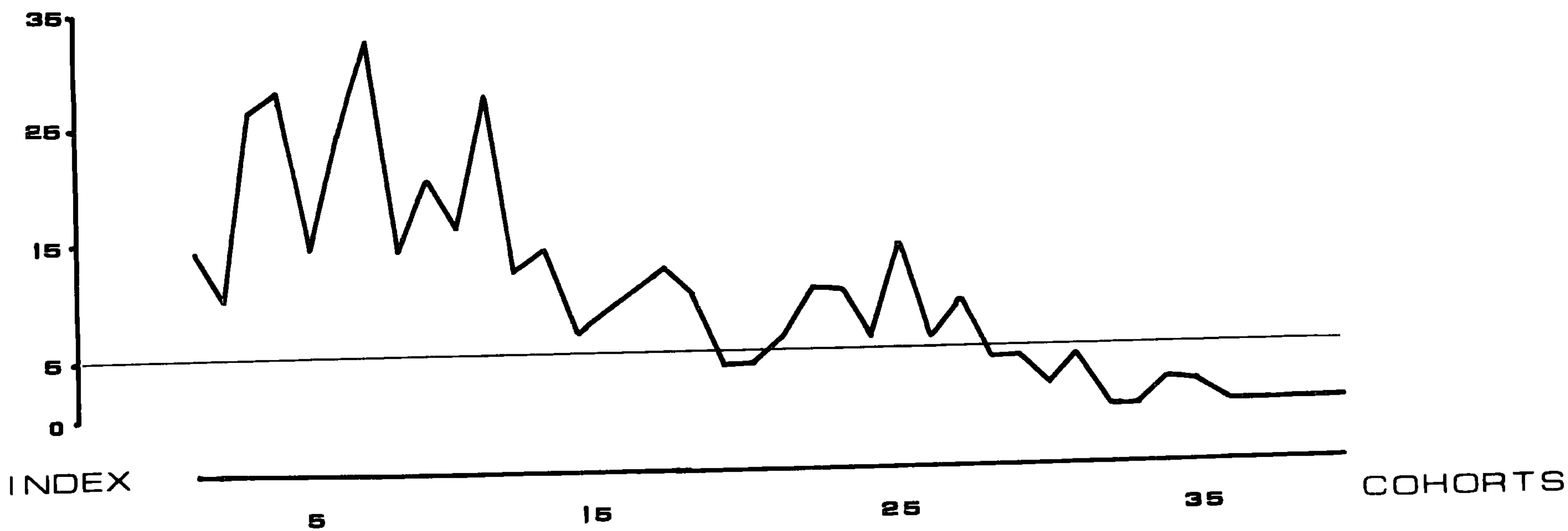
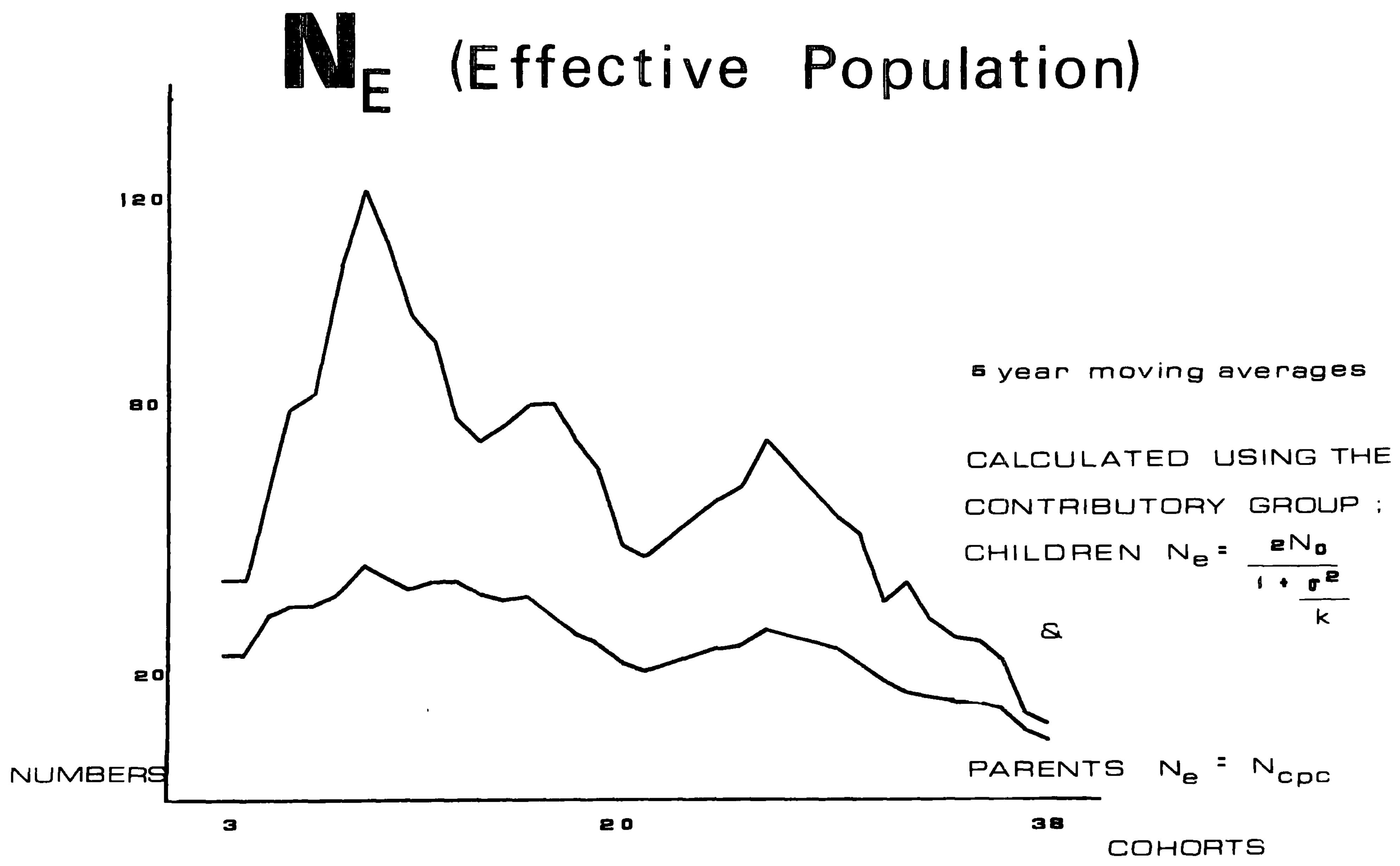


Figure (66)



N E (Effective Population)
120
80
20
NUMBERS
3
20
38
COHORTS
5 year moving averages
CALCULATED USING THE
CONTRIBUTORY GROUP ;
CHILDREN $N_e = \frac{2N_0}{1 + \frac{\sigma^2}{k}}$
&
PARENTS $N_e = N_{cpc}$

endogamy also produces the same type of effect by limiting the gene pool in some generations and it has been shown that certain couples contribute a considerable number of descendants to later cohorts. Similarly it has been shown that the acceptance of marriage partners and new couples into the community over the years has remained constant by proportion to the size of the whole population. Also the proportion of individuals who later become parents has changed little with time. That is to say,although from time to time absolute numbers are controlled by economic factors,those who contribute genetically to the next island generation are influenced by the numbers in the group and many social factors,for example,do not appear to be important. Hence the concept of randomness of genetic action.

A further aim of the presentation of the demographic material in this way is to emphasise the general dynamic nature of the population.

Collation

Part (h) is a general discussion of the applicability of the demographic analysis given in parts (b) to (g) to a genetic study of the island population. For purposes of illustration it is possible to calculate an index of isolation after Lasker (1960),for the longitudinal island population. This shows a low index value for the last ten cohorts, indicating a potential drift situation. The effective population may be estimated using the parental and child populations in each cohort; the moving averaged values demonstrate a small population at all stages in the recorded history of the island. The section on marriage (part(e)) indicates that the breeding population,of which the island is a part, is large and that the cohorts of the island population in no way reflect this group. The results given in this part indicate a mode of analysis rather than a meaningful set of results for the island. Despite this the second chapter continues to consider the island as a unit. This is purely for practical purposes : no study could be large enough to include its entire breeding unit. For this reason it is valuable at this stage to note that the crude analysis in this part and the analyses in parts (e),(f) and (g) all indicate that a random or drift effect may well be in operation on the island and perhaps in the larger breeding unit of which the island is a part. There is no evidence for the latter statement,however. The drift situation seems to be especially marked amongst the core island population which will have a much smaller breeding unit than the total island population. The next chapter will consider if these processes have any effect on the present gene distributions on the island.

Summary of Chapter One

This chapter has been a study of the social history,historical demographic trends,the demography of the living group and includes aspects of the genetic demography of the Holy Island population. It has become apparent as the chapter progressed that the island population is by no means a single unit; historically,socially or genetically. Part (a) indicates why this is not so historically and geographically. Part (c) shows the vital trends and part (d) the census results of the mid-nineteenth century;both parts show the dependance of the community on the outside world. Part (b) introduces the major modes of analysis and this is continued in parts (e) and (f),again showing the relationships of the community with other groups. Part (g) continues the analysis of the living island group which shows similar trends to the historical populations. Finally part (h) introduces some of the demographic data to a genetic interpretation to provide a link with the next chapter.

CHAPTER TWO

Non-Medical Variability

in Holy Island

Part (i)

Introduction to the Non-Medical Tests

This chapter includes all the available information on normal population variability which was collected during the winter of 1969 to 1970.

Collection

30 ml of venous blood was obtained from each individual and in addition a sample of saliva, a sample of urine, palmar dermatoglyphics and skin recordings from an EEL reflectance spectrophotometer, were collected. The results of PTC tasting and a series of miscellaneous data are also reported in this chapter. **12 to 18 people were tested each week and the collected specimens dealt with promptly.**

Blood

The *tubes of blood was placed in cooled Dewar flasks soon after collection. Some was sent for testing at the Pathology Laboratory of the Gateshead Queen Elizabeth Hospital (see chapter three). The rest of the blood was used for genetic studies, whilst the serum was separated from a clotted specimen and the rest of the clot made into a red blood cell lysate. The blood grouping, serum separation and lysate manufacture were all done within 24 hours of collection and the serum and blood lysates were then stored in a deep frozen state.

Saliva

The saliva specimens were boiled in containers on a water bath on the island and placed in a refrigerator within twelve hours of collection.

*** 5ml sequestrene x 2,2ml. fluoride,2x9ml clotted.**

Urine

(20 ml)

The urine was a morning specimen and was tested with a quick screening test (Labstix) soon after collection. Then thymol crystals were added and the urine was placed in a deep freezer within 18 hours of being produced.

Palm Prints

The palm prints were taken by the Kleenprint technique using a cardboard cylinder as a roller. These were numbered and stored in polythene bags until analysed.

Other Data

All other results were noted down on forms bearing the individual's number. Key cards with the number and the name and address of the person were made and kept separate from the rest of the material. These cards also contain the ages and some relationships of the individual. The forms contained data on the PTC threshold, skin colour reflectance values at wavelengths 601, 605 and 609, handedness, joint sense, colour vision anomalies, tongue rolling, finger length and the ability to smell potassium cyanide.

Control Groups

For the purpose of this thesis it has not been possible to obtain a suitable mainland sample to use as a control. This topic is dealt with in more detail later in part (n). However additional material has been collected and used for comparative purposes. These are groups from mainland Northumberland, Northern students from Durham University and other series from schools in the North of England. The 'mainland

Northumberland' series consists of adults from Berwick,Alnwick,Wooler and Bamburgh chosen by having no Irish or highland Scottish surnames and by being born within these parts of Northumberland. Data from Kopeć (1970),Fraser Roberts (1953) and other authors have also been used where appropriate.

Population Subdivisions

The living population on Holy Island may be divided into three groups. These same subdivisions have been used in the first chapter of this thesis. They are briefly given here :

Group (a) is the long standing island population.

Group (b) the non-island spouses of group (a).

Group (c) the rest of the population.

The three groups are distinct genetically; the first representing the ongoing gene pool on the island,the second the gene flow onto the island and the third group is genetically distinct and,by definition, non-contributory to the other two groups.

The island population has been compared with other populations using a variety of sub-samples. The whole island sample has been used occasionally; this is an amalgamation of all three groups on the island and the main reason for its use is one of size. The island subdivisions are all very small and the total island sample has been used to obtain the biggest sample possible. There is no proper justification for this action in genetic terms. Many other mainland samples do not take into account the composition of their samples and must include individuals in the equivalent of the above three groups. Group (a) and group (b) are quoted separately because they are genetically meaningful results for the population for one generation. It can be argued that the island is not an effective genetic unit but because little is known of comparable situations the results are recorded here in detail.

Part (j)

The Methods Used

The material was collected in small batches and dealt with each week.

Blood Group Serology

The following blood transfusion centres kindly provided antisera for this study. Lancaster sub-centre N.B.T.S. (anti-P_1,Lewis (a) and (b) and Rhesus C,D,E and c and H); Newcastle N.B.T.S. (anti-A,B,A_1,M, N,S and Kell); the Lister Institute (anti-Duffy (a),C^W and Lutheran (a)); Ortho Pharmaceuticals (e,k and s); Biotest Laboratories (anti-Duffy (b) and Kidd (a) and (b)) and Hyland Laboratories (anti-H).

The serological techniques varied with the type of antisera used. There are three main methods. The tile technique involves the use of equal volumes of antisera and a 4% red blood cell suspension. The cells are mixed and left for a specific length of time at a certain temperature. The tile is then rocked gently and inspected for agglutination. The following antisera required a tile technique; A,B,AB,A_1,M,N,P_1. Whenever doubtful reactions arose the blood was retested using another batch of the serum and,preferably,another method.

The second method was the simple tube test. This technique involves placing equal volumes of cells with antisera in precipitin tubes which are again left for specific periods of time at specific temperatures. Often the addition of papain or albumin enhances the reaction. The following antisera required this method; C,c,D,E,e,C^W,Lu(a),Le(a),Le(b) and S. The rest of the blood grouping was performed by the Coombs technique. Here the serum is incubated with a 5 to 6% cell suspension at 37°C. Afterwards the cells are washed free of the antisera and placed on a clean tile with a drop of anti-human globulin. The tile is rocked and the mixture is inspected for agglutination. This method was used with the following antisera; s,k,Fy(a),Fy(b),Jk(a) and Jk(b).

The D antisera used had strong anti-D^u properties and no further tests on D negative cells were made. The A_1 negative cells were classed as 'A_2' without further investigation. All the M,N and D tests were done in duplicate. The Lewis,P and S groups were always tested first whilst the blood was less than 18 hours old. Some antisera required traces of complement and for this the cells were only washed once prior to testing. All the other cells used in the other serological tests were washed three times. Every result was checked by two people. Wherever possible the same batch of antiserum was used for the whole series. In this respect the anti-P_1 was an exceptionally strong antiserum and so can only be compared with similarly tested series.

All cells had negative and positive controls set up with them; these were obtained from Lancaster,Newcastle and Ortho.

Secretor Status

The centrifuged and boiled saliva was tested against two series of anti-H. Equal volumes of the saliva and anti-H were incubated at room temperature in a precipitin tube. The presence or otherwise of the anti-H was then demonstrated by the addition of a suspension of fresh blood cells of group O type. If after further incubation the mixture in the tube was not agglutinated then all the anti-H has been neutralised by the secreted blood group substances in the saliva and thus the individual is an ABH secretor. If agglutination occurs then the individual is a non-secretor.

Serum Groups

The serum was stored in a deep frozen state until used. Horizontal starch gel electrophoresis based on the method of Smithies (1955) was used as a screening proceedure for the serum proteins. One half of the gel was stained with 1% amido-black to demonstrate the general protein run, especially the transferrins. The other half of the gel was stained with benzidene after the method of Smithies (1959) to show the haemoglobin bound to the haptoglobin bands. One drop of fresh 4% haemoglobin solution was placed with three drops of the sera prior to electrophoresis. The Ag groups were detected by the use of appropriate antisera and the tests were performed by Mr.D.Tills at the M.R.C. Serological Population Genetics Laboratory.

Red Blood Cell Isoenzymes

The lysates were prepared from clots and deep frozen until required. Horizontal starch gel electrophoresis was used to detect all the following isoenzymes. The basic references for the methods used are given in brackets after the name of each enzyme. The following were run in Durham : Acid Phosphatase (Hopkinson et alia 1963), Phosphoglucomutase (Spencer et alia 1964), Adenylate Kinase (Fildes and Harris 1966), Lactate Dehydrogenase (Davidson et alia 1965), 6-Phosphogluconate Dehydrogenase (Fildes and Parr 1963) and Glucose-6-Phosphate Dehydrogenase (WHO 1966). The following were performed at the Serological Laboratory of Dr.A.E.Mourant by Mr.D.Tills : Adenosine Deaminase (Spencer et alia 1968) and Phospho-Hexose Isomerase (Detter et alia 1968).

Urine Analysis

As well as being screened for medical abnormalities the urine was also stored and then subjected to high voltage electrophoresis to determine the concentration of beta amino isobutyric acid amongst the island population. The analysis was performed at 4500 volts after the method of Gartler (1961), the population being divided into those who excrete high (detectable) quantities of the amino-acid and low (not detectable) quantities.

PTC Tasting

This substance shows a tasting polymorphism when serially diluted and the method is basically after Harris and Kalmus (1949). The technique was modified by Sunderland (1966). This entails omitting a number of the dilutions to speed up the method. The test is in two parts, the first giving the approximate and the second the true threshold. Fresh solutions were made regularly and all the tests were performed in the same way.

Anomalous Colour Vision

A screening method was used here involving the 24 plate Ishihara chart (1960). These plates were read 20 cm from the eye in good daylight. Up to three mistakes were allowed before any note was made of anomalous colour vision. Protanope and deuteranope estimations were made from the final pair of plates in this series.

Collation

Parts (i) and (j) introduce this chapter by recording the modes of collection of the data from the living island population. This is followed by a brief reintroduction of the subdivisions of the Holy Island population given first in part (b). The methods used to determine the unifactorial traits are basically those of other research workers and appropriate references are given. If there are any minor differences in technique which could influence the results these are mentioned here or later in the chapter. Full descriptive details of techniques are not given as it is felt that the emphasis should be placed on the results and their interpretation,whilst it is accepted that each technique used has its own sources of error attatched to it. Other than through the use of controls in red cell serology,it has not been possible to calculate or allow for errors associated with the techniques.

Part (k)

The Unifactorial Traits

This is a long section which firstly shows all the results and a series of simple chi-squared tests (Figures 67 and 68). Each trait is then considered in turn and finally a discussion notes some generally applicable points.

The Results

In the following figures some abbreviations are used. 'Mainland control' refers to the random series of circa 150 individuals from North Northumberland. 'Student control' is the sample of circa 200 people from the North of England, whilst 'Kopeć' and 'Fraser Roberts' both refer to data found in Kopeć (1970) and Fraser Roberts (1953) respectively. Not all data are available universally and so the blanks in the following tables indicate where such omissions occur. The various bracketed figures are phenotype percentages. These are not given for group (c).

Figure (67) shows the main series of results as phenotypes. Blood group P refers to that particular segment of the P range detected by the available antisera (see Race and Sanger 1968). All Kell negatives were tested with cellano and found to be positives. The student series was not tested with anti-Duffy (b). The mainland series were poorly controlled for the Lewis groups due to the lack of cells of the appropriate type.

Figure (68) shows a series of 2 x 2 chi-squared tests on the results shown in Figure (67). Pairs of populations which were compared depended on sample sizes and the avaiability of the results. The 5% level of probability was counted as being most useful and the chi-squared values are given only for results significant at levels of 10% or less.

Figure (67)

The Unifactorial Results : Numbers and Percentages

	Phenotype	Holy Island; Group (a)	Group (b)	(c)	Totals	Comparative Groups; Mainland	Students
ABO	A_1	12 (13.5)	12 (50.0)	8	32 (24.8)	33 (22.9)	69 (33.0)
	A_2	10 (11.2)	0	3	13 (10.1)	11 (7.6)	13 (6.2)
	B	12 (13.5)	2 (8.3)	2	16 (12.4)	18 (12.5)	20 (9.6)
	O	52 (58.4)	10 (41.7)	3	65 (50.4)	74 (51.4)	102 (48.8)
	A_1B	3 (3.4)	0	0	3 (2.3)	6 (4.2)	4 (1.9)
	A_2B	0	0	0	0	2 (1.4)	1 (0.5)
		89	24	16	129	144	209
Rhesus	CC	15 (16.9)	4 (16.7)	1	20 (15.7)	22 (17.9)	
	Cc	44 (49.4)	11 (45.8)	9	64 (50.4)	53 (43.1)	
	cc	30 (33.7)	9 (37.5)	4	43 (33.9)	48 (39.0)	
	DD/Dd	74 (83.1)	23 (95.8)	12	109 (85.8)	91 (74.0)	
	dd	15 (16.9)	1 (4.2)	2	18 (14.2)	32 (26.0)	

Figure (67) **continued**

		Group (a)	Group (b)	(c)	Totals	Mainland	Students
Rhesus	EE	1 (1.1)	1 (4.2)	0	2 (1.6)	4 (3.3)	
	Ee	22 (24.7)	10 (41.7)	6	38 (29.9)	26 (21.1)	
	ee	66 (74.2)	13 (54.1)	8	87 (68.5)	93 (75.6)	
		89	24	14	127	123	
MNSs	MN	71 (79.8)	19 (79.2)	9	99 (76.7)	73 (50.7)	
	MM	10 (11.2)	3 (12.5)	3	16 (12.4)	46 (31.9)	
	NN	8 (9.0)	2 (8.3)	4	14 (10.9)	25 (17.4) *	
	SS	15 (16.9)	3 (12.5)	3	21 (16.3)	12 (10.4)	
	Ss	45 (50.5)	9 (37.5)	9	63 (48.8)	47 (40.9)	
	ss	29 (32.6)	12 (50.0)	4	45 (34.9)	56 (48.7)	
		89	24	16	129	115	
P_1	P+	74 (80.4)	21 (87.5)	14	109 (82.6)	115 (79.9)	156 (74.3)
	P-	18 (19.6)	3 (12.5)	2	23 (17.4)	29 (20.1)	54 (25.7)
		92	24	16	132	144	210

* This M/N column summates to 144 whilst the others are the same as the S/s columns.

Figure (67) continued

	Group (a)	Group (b)	(c)	Total	Mainland	Students
Kell K+	6 (6.7)	3 (12.5)	0	9 (7.0)	12 (8.3)	15 (8.7)
K-	83 (93.3)	21 (87.5)	16	120 (93.0)	132 (96.7)	157 (91.3)
	89	24	16	129	144	172
Lutheran Lu(a)+	10 (11.5)	3 (13.0)	3	16 (13.0)	10 (8.1)	19 (11.0)
Lu (a)-	77 (88.5)	20 (87.0)	10	107 (87.0)	113 (91.9)	153 (89.0)
Duffy Fy (a+b-)	51 (58.0)	3 (14.2)	3	57 (46.7)	27 (27.0)	Fy (a)+ 105 (50.2)
Fy (a+b+)	12 (13.6)	9 (42.9)	7	28 (23.0)	35 (35.0)	Fy (a)- 104 (49.8)
Fy (a-b+)	25 (28.4)	9 (42.9)	3	37 (30.3)	38 (38.0)	
	88	21	13	122	100	209
Lewis Le (a+b-)	15 (17.9)	6 (27.3)	0	21 (17.3)	17 (17.9)	57 (27.9)
Le (a-b+)	60 (71.4)	16 (72.7)	14	90 (74.4)	64 (67.4)	134 (65.7)
Le (a-b-)	9 (10.7)	0	1	10 (8.3)	14 (14.7)	13 (6.4)
	84	22	15	121	95	204

Figure (67) continued

		Group (a)	Group (b)	(c)	Total	Mainland	Students
Kidd Jk (a+b-)		14 (16.9)	5 (25.0)	4	23 (19.8)	30 (29.7)	
Jk (a+b+)		45 (54.2)	11 (55.0)	6	62 (53.5)	40 (39.6)	
Jk (a-b+)		24 (28.9)	4 (20.0)	3	31 (26.7)	31 (30.7)	
		83	20	13	116	101	
Secretor	Se	64 (80.0)	18 (78.3)	15	97 (82.2)		114 (82.0)
Status	sese	16 (20.0)	5 (21.7)	0	21 (17.8)		25 (18.0)
		80	23	15	118		139
Haptoglobin	1-1	14 (16.9)	7 (28.0)	1	22 (18.0)	23 (18.9)	33 (16.0)
	2-1	33 (39.8)	8 (32.0)	6	47 (38.5)	69 (56.6)	104 (50.5)
	2-2	36 (43.3)	10 (40.0)	7	53 (43.5)	30 (24.6)	69 (33.5)
		83	25	14	122	122	206
Ag types	Ag(x)+	33 (42.3)	7 (31.8)	4	44 (40.7)		
	Ag(x)-	45 (57.7)	15 (68.2)	4	64 (59.3)		
		78	22	8	108		

Figure (67) **continued**

		Group (a)	Group (b)	(c)	Total	Mainland	Students
Transferrins	CC	83 (100)	25 (100)	14	122 (100)		205 (99.5)
	BC	0	0	0	0		1 (0.5)
		83	25	14	122		206
6-Phosphogluconate	AA	80 (96.4)	24 (96.0)	14	118 (96.7)		
dehydrogenase	CA	3 (3.6)	1 (4.0)	0	4 (3.3)		
		83	25	14	122		
Acid Phosphatase	AA	7 (8.0)	1 (4.0)	1	9 (7.0)	13 (10.6)	31 (16.9)
	BA	48 (54.5)	14 (56.0)	7	69 (53.9)	50 (40.7)	66 (35.9)
	BB	25 (28.4)	9 (36.0)	5	39 (30.5)	51 (41.4)	74 (40.2)
	CB	6 (6.8)	1 (4.0)	2	9 (7.0)	8 (6.5)	10 (5.4)
	CA	2 (2.3)	0	0	2 (1.6)	1 (0.8)	3 (1.6)
		88	25	15	128	123	184
Phosphoglucomutase	11	47 (54.0)	12 (48.0)	14	73 (57.5)	78 (65.6)	75 (46.0)
	2-1	28 (32.2)	12 (48.0)	1	41 (32.3)	38 (31.9)	75 (46.0)
	2-2	12 (13.8)	1 (4.0)	0	13 (10.2)	3 (2.5)	13 (8.0)
		87	25	15	127	119	163

Figure (67) continued

		Group (a)	Group (b)	(c)	Total	Mainland	Students
Adenylate	1-1	81 (92.0)	21 (87.5)	15	117 (92.1)	118 (95.9)	193 (92.3)
kinase	2-1	6 (6.8)	3 (12.5)	0	9 (7.1)	5 (4.1)	16 (7.7)
	2-2	1 (1.2)	0	0	1 (0.8)	0	0
		88	24	15	127	123	209
Adenosine	1-1	62 (70.5)	20 (83.3)	14	96 (75.6)		
deaminase	2-1	22 (25.0)	4 (16.7)	1	27 (21.3)		
	2-2	4 (4.5)	0	0	4 (3.1)		
		88	24	15	127		
Phospho- hexoseisomerase	Normal	78 (100)	22 (100)	8	108 (100)		
Lactate dehydrogenase	Normal	83 (100)	25 (100)	14	122 (100)		
Glucose-6-Phosphate dehydrogenase	B	83 (100)	25 (100)	14	122 (100)		

Figure (67) continued

		Group (a)	Group (b)	(c)	Total	Mainland	Students
PTC tasting	T	49½ (57.6)	16 (76.2)	10	75½ (61.9)	243½ (73.6) *	
	tt	36½ (42.4)	5 (23.8)	5	46½ (38.1)	87½ (26.4)	
		86	21	15	122	331	
Male Colour	Normal	48 (98.0)	6 (100)	5	59 (98.3)	214 (91.8) *	
Blind	Anomalous	1 (2.0)	0	0	1 (1.7)	19 (8.2)	
Female Colour	Normal	38 (100)	18 (100)	10	66 (100)	155 (100) *	
Blind							
BAIB excretion	High	9 (11.0)	4 (17.4)	3	16 (13.3)		15 (7.4)
	Low	73 (89.0)	19 (82.6)	12	104 (86.7)		189 (92.6)

* This mainland sample is of schoolchildren and differs from the one on previous pages of this figure.

Figure (68)

The Holy Island Population - Tests of Significance

This is a series of 2 x 2 chi-squared tests on the various phenotype samples found in Figure (67). 'NS' indicates a non-significant result at a probability level of over 10%.

The 2 x 2 tests are to maximise group differences.

System		Holy Island Group (a) versus Mainland	Holy Island Group (a) versus Students
ABO	A_1 v. Rest	3.15 NS 5-10%	12.05 S less than .1%
	A_2 v. Rest	NS	NS
	O v. Rest	NS	NS
	B v. Rest	NS	NS
			Holy Island Total v. Mainland
Rhesus	CC v. Rest	NS	NS
	Cc v. Rest	NS	NS
	cc v. Rest	NS	NS
	dd v. Rest	NS	5.48 S 1-2½%
	Ee v. Rest	NS	NS
	ee v. Rest	NS	NS
			Holy Island Total v. Students
MNSs	MM v. Rest	12.94 S less than .1%	-
	MN v. Rest	19.72 S less than .1%	-
	NN v. Rest	3.17 NS 5-10%	-
	SS v. Rest	NS	-
	Ss v. Rest	NS	-
	ss v. Rest	5.38 S 1-2½%	-
P	P+ v. P-	NS	3.18 NS 5-10%
Kell	K+ v. K-	NS	NS
Lutheran	Lu(a)+ v. Lu(a)-	NS	NS

Figure (68) continued

System		Holy Island Group (a) versus Mainland	Holy Island Total versus Students
Duffy	Fy(b)+ V.Rest	18.50 S under .1%	-
	Fy(a)+ v.Rest	NS	11.94 S less than .1%
	Fy(ab)+ v.Rest	11.39 S under .1%	-
Lewis	Le(b)+ v.Rest	NS	NS
	Le(a)+ v.Rest	NS	4.25 S 2½-5%
	Le(ab)-v.Rest	NS	NS
Kidd	Jk(b)+ v. Rest	4.06 S 2½-5%	-
	Jk(a)+ v. Rest	NS	-
	Jk(ab)+v. Rest	3.92 S 2½-5%	-
			Holy Island Group (a) versus Students
Secretor	Se v. sese	-	NS
			Holy Island Total versus Students
Haptoglobin	2-2 v. Rest	8.02 S ½-1%	3.25 NS 5-10%
	2-1 v. Rest	5.58 S 1-2½%	4.45 S 2½-5%
	1-1 v. Rest	NS	NS
Acid Phosphatase			
	AA v. Rest	NS	6.49 S 1-2½%
	BA v. Rest	3.95 S 2½-5%	9.98 S .1-½%
	BB v. Rest	3.80 NS 5-10%	3.14 NS 5-10%
Phosphoglucomutase			
	1-1 v. Rest	NS	3.77 NS 5-10%
	2-1 v. Rest	NS	5.61 S 1-2½%
	2-2 v. Rest	-	NS
Adenylate Kinase			
	1-1 v. Rest	NS	NS

Figure (68) continued

System		Holy Island Group (a) versus Londoners
Adenosine Deaminase	1-1 v. Rest	8.4 S .1-½%
	2-1 v. Rest	22.3 S less than .1%
		Holy Island Group (a) versus Mainland Northumberland
PTC tasting	T v. tt	6.16 S 1-2½%
		Holy Island Group (a) versus Students
BAIB excretion	High v. Low	NS
		Holy Island Group (a) versus Swedes
Ag(x) type	Ag(x)+ v. Ag(x)-	NS

The following were not tested by the chi-squared method due to the small numbers involved or the lack of phenotypic variation. The results apparently showed no variation when contrasted with other English series.

Colour Blindness
Transferrin subtypes
Phosphohexose Isomerase
Lactate Dehydrogenase
Glucose-6-Phosphate Dehydrogenase
6-Phosphogluconate Dehydrogenase

The ABO Blood Group System

The properties of this blood group system were the first to be investigated (Landsteiner 1900) and during the Great War distributional studies were undertaken and later published (Hirschfeld and Hirschfeld 1919). Since then large collections of regional and local population studies have been published by Boyd (1939),Mourant (1954), Mourant et alia (1958) and Kopeć (1970). The recorded work is often based upon data from the National Blood Transfusion Service in this country. In large samples this compares well with series from servicemen (Kopeć 1970). However this is not always the case with small samples and this problem will be discussed later. If further selection of a donor sample takes place by age,or birth locality,then it is likely that an excess of donor type O individuals appear. This is noted in the mainland sample and other studies have shown discrepancies between donor and other samples (Mitchell 1971). This observation is not fully understood.

The student control group was extracted from a series of new donors attending sessions in Durham. This series is used to compare with group (a) inhabitants in Figure (67). The Kopeć material used in Figure (69) is from donors attending sessions at Berwick and Alnwick. The 'mainland series' includes data from individuals born and still living near Berwick,Alnwick,Seahouses and Wooler. Both the Kopeć and Fraser Roberts material are from blood donors from similar areas but the data was collected some years ago. Unfortunately there are no means of assessing if any individuals are present in more than one series. *

The presentations of the data in the figures show that the group (a) islanders are deficient in the A_1 gene whilst the group (b) spouses are in the process of introducing this particular gene on the island. Statistically significant comparisons are shown in Figure (68). The

* The mainland series was not exclusively new donors.

Figure (69)

Further ABO Results Without A_1 (i.e. tested only with anti-A)

	Holy Island Group (a)	Group (b)	(c)	Total	Mainland	Kopeć *	Fraser Roberts **	Students
A	22 (24.7)	12 (50.0)	11	45 (34.9)	44(30.5)	249 (38.2)	295 (36.0)	82 (39.2)
B	12 (13.5)	2 (8.3)	2	16 (12.4)	18(12.5)	64 (9.8)	75 (9.1)	20 (9.6)
O	52 (58.4)	10 (41.7)	3	65 (50.4)	74(51.4)	319 (48.9)	434 (52.9)	102 (48.8)
AB	3 (3.4)	0	0	3 (2.3)	8(5.6)	20 (3.1)	16 (2.0)	5 (2.4)
Totals	89	24	16	129	144	652	820	209

* Berwick,Alnwick,Seahouses and Wooler

** Berwick,Alnwick,Ellingham and Netherwitton

A_1 gene was,in the past,replaced by the O gene amongst the long-standing island community. The mainland series and the Kopeć and Fraser Roberts results do not differ markedly in respect of the totalled island results,nor do they differ very much from each other. This homogeneity is confirmed by the non-significant results for the chi-squared tests seen in Figure (68).

In toto the Holy Island material fits in well with the regional scheme of Kopeć (1970) and with earlier publications. The ABO data along with results of Rhesus D,PTC and anomalous colour vision,are unusual in that the British Isles data are sufficiently detailed to be able to make,if desired,more detailed comparisons than are possible with the rest of the results in this chapter. No attempts are made to effect such comparisons in this thesis; the significance of such geographical comparisons is discussed at the end of this chapter.

The gene frequencies are recorded in Figure (70). They demonstrate once more the low frequencies of the A_1 gene amongst the core island population. The gene frequencies have been calculated using the simplest method mentioned in Mourant (1954). This is because the demography of the island makes it most unlikely that there will be an expected distribution of heterozygotes amongst the core population. The frequencies are recorded for completeness.

Figure (70)

ABO Gene Frequencies Calculated After Mourant (1954)

Genes	Holy Island Group (a)	Mainland	Fraser Roberts *	Kopeć Alnwick	Kopeć Berwick
A_1	.0775	.1378	-	-	-
A_2	.0706	.0517	-	-	-
A	-	-	.2150	.2078	.2648
B	.0840	.0830	.0610	.0724	.0652
O	.7679	.7275	.7240	.7198	.6700

* Includes Berwick,Alnwick,Ellingham and Netherwitton

The Rhesus Blood Group System

The rhesus system was first investigated by Landsteiner and Wiener (1940) subsequent to the observations of Levine and Stetson (1939). The complexity of the system was soon recognised and the synthesis by Fisher (1943) is used in the results given here, whilst the Wiener code is employed in a modified form to indicate the chromosome complexes as cited by Race and Sanger (1968) and given by Heiken and Rasmusen (1966). Thus C/C^W +,C^W -,c +,D +,E -,e + are taken to indicate the phenotype R_1r and the chromosome composition CDe/cde although a small proportion would be CDe/cDe and cDe/Cde. Sample bias is to be expected in relation to rhesus negative people collected in the samples from the blood transfusion service. There seems to be a good deal of heterogeneity amongst the number and proportion of rhesus negative individuals in the control groups and this is significant in one comparison shown in Figure (71) between rr versus the rest using the Holy Island total versus the mainland. The mainland sample has an abnormally high frequency of the rr combination. There are differences when comparisons are made between the chromosomal combinations but most of these are not significant. The islanders seem to have high r gene estimations and to be low in R_2 combinations. This is being stabilized to some extent by the group (b) individuals who are low in r groups and high in the R_2 chromosome. A wide measure of chromosomal variation is only to be expected with so many varying and associated chromosomal complexes. In most cases the sample sizes are too small to be useful statistically.

Figure (67) gives the gene combinations deduced from the serology (C,c,E and e) and for the Dd combinations assuming the commonest rhesus chromosome types. The differences between the island and the

Figure (71)

Holy Island
Further Rhesus Results :
Chromosome Estimates with C^{w}

	Holy Island :				Mainland
	Group (a)	(b)	(c)	Total	
rr	14(15.7)	1(4.2)	2	17(13.4)	30(24.4)
R_1r	36(40.5)	6(25.0)	4	46(36.2)	40(32.5)
R_1R_1	15(16.9)	4(16.6)	1	20(15.7)	21(17.1)
R_2r	14(15.7)	6(25.0)	2	22(17.3)	12(9.8)
R_1R_2	7(7.9)	4(16.6)	4	15(11.8)	11(8.9)
R_2R_2	1(1.1)	1(4.2)	0	2(1.6)	4(3.3)
rr''	1(1.1)	0	0	1(0.8)	2(1.6)
R_1^wr	1(1.1)	1(4.2)	1	3(2.4)	1(0.8)
R_or	0	1(4.2)	0	1(0.8)	0
$R_1^wR_1$	0	0	0	0	1(0.8)
$R_1^wR_2$	0	0	0	0	1(0.8)
Total	89	24	14	127	123

Chi-squared test results;

	Holy Island Group (a) versus Mainland	Holy Island Total versus Mainland
rr v. rest	NS	4.99 S at 1-2½%
R_1r v. rest	NS	NS
R_1R_1 v. rest	NS	NS
R_2r v. rest	NS	3.01 NS 5-10%

Figure (71) continued

Rhesus D.

	Holy Island Group(a)	(b)	(c)	Total	Elsewhere Mainland	Kopeć	Students
rr	14 (15.7)	1(4.2)	2	17(13.4)	34(23.6)	136(20.7)	38(18.1)
r'r	0	0	0	0	0	2(0.3)	0
r"r	1 (1.1)	0	0	1(0.8)	2(1.4)	2(0.3)	0
r'r"	0	0	0	0	0	0	0
R types	74 (83.2)	23(95.8)	12	109(85.8)	108(75.0)	516(78.7)	172(81.9)
Totals	89	24	14	127	144	656	210

Chi-squared test results; rr versus rest

Holy Island group(a) versus Kopeć

NS

Holy Island Total versus Kopeć

3.64 NS 5-10%

Holy Island group (a) versus Students

NS

Holy Island Total versus Students

NS

Figure (71) continued

Chromosome Estimates without C^W

Complexes	Holy Island Group (a)	(b)	(c)	Total	Mainland
R_1r	37 (41.6)	7 (29.2)	5	49 (38.6)	49 (34.0)
rr	14 (15.7)	1 (4.2)	2	17 (13.4)	34 (23.6)
R_1R_1	15 (16.9)	4 (16.6)	1	20 (15.7)	25 (17.4)
R_2r	14 (15.7)	6 (25.0)	2	22 (17.3)	14 (9.7)
R_1R_2	7 (7.9)	4 (16.6)	4	15 (11.8)	14 (9.7)
R_2R_2	1 (1.1)	1 (4.2)	0	2 (1.6)	6 (4.2)
R_or	0	1 (4.2)	0	1 (0.8)	0
rr"	1 (1.1)	0	0	1 (0.8)	2 (1.4)
Totals	89	24		127	144

Chromosomes (estimated by gene counting)

	Group (a)	(b)	(c)	Total	Mainland
r	40 (44.9)	8 (33.3)	5½	53½(42.1)	66½(46.2)
R_1	37 (41.6)	9½(39.6)	5½	52 (41.0)	56½(39.2)
R_2	11½(12.9)	6 (25.0)	3	20½(16.1)	20 (13.9)
R_o	-	½(2.1)	-	½(0.4)	-
r"	½(0.6)	-	-	½(0.4)	1 (0.7)

Willis subtype

	Group (a)	(b)	(c)	Total	Mainland
C^W +	1	1	1	3	3
C^W -	88	23	13	124	120

Chromosomes (estimated after Mourant 1954)

	Group (a)	(b)	Total	Mainland
r	.4419	.4667	.3983	.4857
R_1	.4160	.3960	.4090	.3945
R_2	.1203	.2505	.1555	.1241
R_o	0	.1854	.0116	0
r"	.0142	0	.0100	.0144

mainland samples reflect the high proportions of c,d,e on the mainland. Figure (68) gives the chi-squared results for these phenotypes and once more shows the significant differences in association with the mainland series.

A large series of donor results are available for the British Isles (Kopeć 1970),Figures (71) and (72) demonstrate these results. The results show wide fluctuations in the D positive frequencies between neighbouring districts and so the differences between the island and elsewhere cannot be regarded as unusual.

The frequency of the C subtype Willis does not vary very much between the island,mainland and other British series.

<u>The MNSs Blood Group System</u>

This system was investigated by Landsteiner and Levine and published as a series of papers (Landsteiner and Levine 1927a,1927b, 1928) for the M and N factors. Later S was studied by Walsh and Montgomery (1947),Sanger and Race (1947) and Sanger et alia (1948) and s was investigated by Levine et alia (1951).

The results from the present study are recorded in Figures (67),(73),(74) and (75). In the past differing techniques and the varying titre of antisera have been responsible for some inconsistencies in the results. In this series all tests for M and N were duplicated and the same batches of antisera used throughout. The results for the student series are not included as these precautions were not followed.

Differences between the island and mainland occur at all levels of phenotypic and genotypic comparison (Figures (67) and (73)). The heterozygote MNSs is twice as common on the island as elsewhere whilst the homozygote MMss is almost deficient and the combination NNss is rare,when comparisons are made with control groups. The genes N and

Figure (72)

Holy Island

Estimated Chromosome Frequencies taken from English

and Irish Sources

Complex	English Murray (1946)	English Race (1950)	Irish Huth (1953)	Holy Island (this study)	Mainland
r	38.9	39.7	43.9	44.9	46.2
R_1	43.1	40.7	40.4	41.6	39.2
R_2	13.7	16.2	10.5	12.9	13.9
R_o	2.8	0.9	3.4	0	0
r''	0.8	1.6	0.6	0.6	0.7
r'	0.7	0.8	0.6	0	0
R_z	0	0.1	0.6	0	0
Total	1012	1107	200	89	144

Figure (73)

Holy Island : Further MNSs Results

Phenotypes

	Holy Island Group (a)	Group (b)	Group (c)	Total	Mainland
MNSs	36 (40.5)	8 (33.3)	5	49 (37.9)	25 (21.7)
MNSS	11 (12.4)	3 (12.5)	3	17 (13.2)	5 (4.3)
MNss	24 (26.9)	8 (33.3)	1	33 (25.6)	27 (23.5)
MMSs	5 (5.6)	1 (4.3)	2	8 (6.2)	18 (15.6)
MMSS	4 (4.5)	0	0	4 (3.1)	7 (6.1)
MMss	1 (1.1)	2 (8.3)	1	4 (3.1)	11 (9.6)
NNSs	4 (4.5)	0	2	6 (4.7)	4 (3.5)
NNSS	0	0	0	0	0
NNss	4 (4.5)	2 (8.3)	2	8 (6.2)	18 (15.7)
Total	89	24	16	129	115

Genes

M	45½(51.1)	12½(52.1)	7½	65½(50.8)	82½(57.3)
N	43½(48.9)	11½(47.9)	8½	63½(49.2)	61½(42.7) *
S	37½(42.1)	7½(31.2)	7½	52½(40.7)	35½(30.9)
s	51½(57.9)	16½(68.8)	8½	76½(59.3)	79½(69.1)

* the MN material contains additional data which makes the summation 144

S are commoner on the island than the mainland, this may be seen in the configurations in Figure (73), in the second half of the table.

The English control quoted by Race and Sanger (1968) and presented in Figure (74) is by Cleghorn (1960). There is a remarkable resemblance between the mainland series and this large sample by Cleghorn. Figure (75) gives Ikin's (1952) regional results (tested without anti-s) and the Holy Island group (a) results are given for comparison. It is difficult to make regional sense out of the Holy Island results and it seems likely that the explanation for gene differences lies elsewhere.

Figure (74)

Holy Island - MNSs Chromosome Frequencies

The rounded off percentage frequencies are given in the brackets

	Mainland	English	Holy Island group (a)	Holy Island total
MNSs	25 (22)	224 (22)	36 (41)	49 (38)
MNSS	5 (4)	39 (4)	11 (13)	17 (13)
MNss	27 (23)	226 (23)	24 (27)	33 (26)
MMSs	18 (16)	140 (14)	5 (6)	8 (6)
MMSS	7 (6)	57 (6)	4 (4)	4 (3)
MMss	11 (9)	101 (10)	1 (1)	4 (3)
NNSs	4 (4)	54 (5)	4 (4)	6 (5)
NNSS	0	3 (0)	0	0
NNss	18 (16)	156 (16)	4 (4)	8 (6)
Total	115	1000	89	129

2 x 2 chi-squared tests on the Holy Island total sample versus the Mainland

MNSs v. Rest	8.76 S .1 to .5%	MNSS v. Rest	5.84 S 1 to 2½%
MNss v. Rest	NS	MNSs v. Rest	5.81 S 1 to 2½%

Figure (75)

Holy Island : MNS Results

	Holy Island Group (a)	English	Welsh	Scottish	Northern Irish
MNS	47 (52)	263(26)	36 (31)	137 (26)	17 (16)
MNss	24 (27)	226(22)	18 (15)	148 (28)	37 (35)
MMS	9 (10)	197(20)	20 (17)	105 (20)	23 (22)
MMss	1 (1)	101(10)	16 (14)	37 (7)	14 (13)
NNS	4 (5)	57(6)	9 (8)	21 (4)	4 (4)
NNss	4 (5)	156(16)	17 (15)	79 (15)	11 (10)
Total	89	1000	116	527	106

Percentages in brackets are rounded off to the nearest whole number

The P Blood Group System

This system was investigated by Landsteiner and Levine (1927b). Many of the frequency differences are due to varying antisera strengths rather than reflecting true genetic heterogeneity. Also there is an age factor operating in that some of the P positive individuals do not develop a positive agglutination until the age of ten or twelve (Race and Sanger 1968). Race and Sanger consider the 'truest' index of Caucasian frequencies to be provided by Henningsen (1949) for Scandinavia : P_1+ at 78.85% (sample size of 2345). However the following regional series are provided by Ikin et alia (1952). All the series in this present study were investigated using comparable antisera from the same laboratory.

Figure (76)

Holy Island : P_1 results for the British Isles

	Number	P + %	P_1 gene
English	1166	76.59	51.61
Welsh	166	73.28	48.31
Scottish	527	75.52	50.52
Northern Irish	106	78.30	53.42
Mainland (this study)	144	79.86	55.12
Students (this study)	210	74.28	49.29
Holy Island (group (a))	92	80.43	55.76
Holy Island Total	132	82.57	58.25

The mainland and island samples are both more frequent in P positives than the Ikin series, indicating a higher Northumberland frequency. This does not seem to be due to the nature of the antisera because the student series is also low.

There are no significant differences displayed in the chi-squared comparisons in Figure (68) and the differences in Figure (76) are also unlikely to be statistically significant. Because of the known differences in antisera, however, it does not seem appropriate to compare them.

The Kell Blood Group System

The first studies on the population frequencies of this system were reported by Race (1946), whilst the results of two large random series of results are to be found in Race and Sanger (1968); one by the authors and the other by Cleghorn. A very large Scottish series is by Rahman (1967) and other regional reports by Ikin (1952) are incorporated into Figure (77).

Figure (77)

Holy Island - Results for the British Isles of the Kell System

	Number	Kell + %	K gene
South English (Race)	1108	8.9	.046
English (Cleghorn)	8767	9.0	.046
Scottish (Ikin)	527	-	.046
Scottish (Rahman)	20000	8.4	.043
Welsh (Ikin)	116	-	.044
Northern Irish (Ikin)	106	-	.039
Students (this study)	172	8.7	.045
Mainland (this study)	144	8.3	.042
Holy Island group (a)	89	6.7	.034
Holy Island Total	129	7.0	.036

A 2 x 2 Chi-squared test of Cleghorn versus Holy Island group (a) is not significant at 5%.

There is no statistically significant difference between any group of Kell results. In fact the student and mainland samples fit in well with the rest of Britain whilst the island has a marginally lower frequency of the K gene.

The Lutheran Blood Group System

This system was initially described by Callender and Race (1946). Ikin (1952) along with Race and Sanger (1968) report regional samples which are incorporated into Figure (78).

Figure (78)

Holy Island - Lutheran (a) results for the British Isles

	number	Lu(a) +	Lu(a) gene
English (Race)	1373	7.65	.039
English (Ikin)	1166	6.09	.031
Welsh (Ikin)	116	0.86	.004
Scottish (Ikin)	527	5.50	.028
Northern Irish (Ikin)	106	8.49	.043
Students (this study)	172	11.04	.057
Mainland (this study)	123	8.13	.042
Holy Island group (a)	87	11.49	.059
Holy Island Total	123	13.00	.067

Statistical comparisons of the material in Figure (68) show no heterogeneity,nor does any difference exist between the Ikin English series and the island group (a) results. However the island shows a higher frequency of the Lu(a) gene than the mainland whilst this Northumberland sample fits in well with the series of Race and Sanger. The Scottish series by Ikin,when compared with the Holy Island group (a) shows a small significant difference (4.58 P= 2½ to 5%).

The Duffy Blood Group System

The Duffy system was investigated by Cutbush and Mollison (1950). There are few regional series reported with both Duffy antisera and those used in Figure (79) are by Chown et alia (1965b) for white Canadians and Cleghorn (1961) for an English series.

The mainland series is fairly close to the English and Canadian results and this is confirmed in the gene estimations, which for comparative purposes ignores the possibility of the existance of the gene Fy.

The Holy Island group (a) series has an excess of the Fy(a) gene. This is particularly seen in the homozygous state and gives the significant results in Figure (68). The general significance of these results is discussed in general terms in part (n).

The Lewis Blood Group System

The Lewis system was described by Mourant (1946) and despite the theory of Grubb and Ceppellini many aspects of the polymorphism are still obscure, for example, the mode of inheritance of the Lewis (b) antigen. Also like the P system there can be considerable variation in results with different batches and sources of antisera and although the same antiserum was used in all the new results given here, the mainland sample was not properly controlled and so may not be reliable. However the student series is similar to the Ikin results while the island results are very different. As before some of the regional samples in Figure (80) are from Ikin (1952).

Figure (68) shows that although the phenotype differences appear large only one chi-squared comparison is statistically significant.

Figure (79)

The Duffy Blood Group Results

Sample	Number	Phenotype Percentages				Gene Frequencies	
		a+b-	a+b+	a-b+	a-b-	Fy(a)	Fy(b)
Canadian (Chown)	1600	19.0	49.1	31.9	0	.4353	.5647
English (Cleghorn)	909	19.5	47.9	32.6	0	.4350	.5650
Mainland (This study)	100	27.0	35.0	38.0	0	.4450	.5550
Holy Island Group(a)	88	58.0	13.6	28.4	0	.6477	.3523
Holy Island Total	122	46.7	23.0	30.3	0	.5819	.4181

Figure (80)
Lewis Phenotype Frequencies

Sample	Number	Phenotype Percentages a+ b-	a- b+	a- b-
English (Ikin)	1166	21.10	71.61	7.29
London (Lincoln)	213	23.00	62.91	14.08
Welsh (Ikin)	116	25.00	68.97	6.03
Scottish (Ikin)	527	28.46	67.74	3.80
Aberdeen (Lincoln)	550	28.00	65.63	6.36
Northern Irish (Ikin)	106	31.13	60.38	8.49
Belfast (Lincoln)	664	26.86	65.37	7.76
Dublin (Lincoln)	597	27.63	64.48	7.87
Students)	204	27.94	65.69	6.37
Mainland) This	95	17.89	67.38	14.73
Holy Is.Gp a) Study	84	17.85	71.43	10.72
Holy Is.Total)	121	17.35	74.39	8.26

Nevertheless there is a general lack of the Lewis(a) positive type on the island. Gene calculations have not been made owing to the uncertain status of the subtypes.

Recently Lincoln and Dodd (1972)have produced new data to suggest further regional variation of this trait. Figure (80) also gives some results extracted from their paper. This shows that the frequency of the type Lewis (a) negative (b) negative fits in quite well with the Holy Island and mainland control series and emphasises the lack of Lewis (a) positive mentioned above.

The Kidd Blood Group System

This system was found by Allen et alia (1951). Few series using both antisera have been described owing to the difficulties encountered with Jk(b) antisera (Race and Sanger 1968). The series of white Canadians (Chown et alia 1965a) shown in Figure (81) has expected values very close to those observed with anti-Jk(a) alone.

Figure (81)

Holy Island - Kidd Results

	Number	a+ b-	a+ b+	a- b+	(a) gene
Canadians (Chown)	1296	26.0	50.3	23.7	.5115
Mainland (this study)	101	29.7	39.6	30.7	.4950
Holy Island group(a)	83	16.9	54.2	28.9	.4397
Holy Island Total	116	19.8	53.5	26.7	.4655

The gene frequencies of the mainland and the Canadian sample are fairly close. The other results show the island deficient in the type Jk(a) positive (b) negative. This is again reflected in the chi-squared results, seen in Figure (68). It is not possible to give an explanation for these results on a regional basis (as with the Duffy results) because of the absence of a suitable series of comparable results.

Secretor Status

The dimorphism of ABH secretion was recognised in the 1930's. However many technical difficulties were experienced and standardisation of the antisera was not achieved for some time. Race and Sanger (1968) quote a series by McConnell from Liverpool as being the most reliable to date. The present series show that some regional variation may exist when comparing the results with McConnell and Lincoln and Dodd (1972). These are given in Figure (82). The North of England seems to have lower frequencies of non-secretors than the rest of the country.

There are no significant differences between Holy Island and the series of Northern students (see Figure (68)). Also the regional differences that have been shown to exist do not fit well into a regional pattern and so these results, like so many in this chapter, cannot be properly evaluated.

Figure (82)

Holy Island : Secretor Status in the British Isles

	Number	Non-secretor Percentage	sese gene
Liverpool (McConnell)	1118	22.72	.477
London (Lincoln)	284	24.29	.493
Aberdeen (Lincoln)	507	29.38	.542
Belfast (Lincoln)	532	30.07	.548
Dublin (Lincoln)	452	32.74	.572
Students (this study)	139	18.00	.424
Holy Island group (a)	80	20.00	.447
Holy Island Total	118	17.79	.422

Serum Haptoglobin Variants

Smithies (1955) was the first to investigate this aspect of human genetic variability. Large collections of world distributional data have now accumulated (Planas 1963 and Giblett 1969) and the results in Figure (83) come from this latter source.

The mainland sample has the highest frequency of the Hp 1 gene described in this country to date and this is reflected in the chi-squared tests in Figure (68). A recent study in Sweden involving some 15,601 unrelated individuals indicates that some genetic heterogeneity is to be found in that country. The regional Hp 1 gene variation ranged from .417 to .348 (Höglund et alia 1970). Such differences may well be emerging in the few recorded results so far published for this country. Certainly the range of gene variation from the above results for this country is about 11% whilst for Sweden is just under 7%.

Figure (83)

Holy Island : Frequency of the Hp 1 Gene

	Number	Hp 1 gene
England	218	0.41
Scotland	100	0.36
Students (this study)	206	0.41
Mainland (this study)	122	0.47
Holy Island group (a)	83	0.37
Holy Island Total	122	0.37

Serum Transferrin Variants

Inherited variants in the serum transferrin part of the general protein run have been found since 1957 (Smithies 1957 and 1958). Smithies and Hiller (1959) proposed the now accepted genetic system of three types of alleles, most of which have been demonstrated as behaving as autosomal co-dominant genes, called B, C and D.

No transferrin variant was found in the mainland or the island samples and only one (a BC type) was found in the series of Durham students. This B variant corresponds to the commoner type found in the Durham laboratory which is taken to be a B_2 type. The frequency of B_2C in Britain is about 2% (Giblett 1962). The results in all the Northern series are therefore lower than expected. Because of the rarity of the variants large samples are required to confirm that sampling error has not been encountered and so little emphasis should be placed on the results.

The Serum Factor Ag(x)

This polymorphism was first described by Allison and Blumberg (1961). The original antisera were shown to be a mixture and modern investigations of the frequency of Ag(x) have been recorded by Hirschfeld and Okochi (1967),Morganti et alia (1967) and Solaas (1970). There is one published paper on frequencies in Britain (Bradbrook et alia 1971) and so Figure (84) includes results from mainland Europe. These latter results are from Solaas (1970).

Figure (84)

Holy Island - Ag gene Frequencies

	Numbers	Ag(x) gene	Ag gene
Swedes	216	0.22	0.78
Swiss	282	0.24	0.76
Norse	3162	0.20	0.80
Italians	334	0.23	0.77
British *	260	0.20	0.80
Holy Island Total	108	0.23	0.77

* Sample tested with anti-Ag(x) only in common with Holy Island

Figure (84) assumes that Ag(x) is the allele to the recessive gene Ag. The sample of Swedes was used to compare with Holy Island group (a) in Figure (67). The results show that the island frequencies are similar to the rest of Europe. However a paper by Persson and Swan (1971) has shown that it is possible for wide gene variations to occur within semi-isolated groups of Greenlanders (Ag(x) varies from .97 to .25). In view of this no useful comment can be made until further British series are reported.

The Red Blood Cell Isoenzyme Acid Phosphatase

This isoenzyme was amongst the first to be elucidated and is unusual in having three common alleles (Hopkinson et alia 1963). The extreme ranges of European variation are reported by Goedde (1970). They are as follows : Pa .310 (Freiberg) to .405 (Leipzig), Pb .643 (Freiberg) to .559 (Leipzig) and Pc .036 (Leipzig) to .064 (Freiberg). Figure (85) gives the gene frequencies for the Northern series found in Figure (67).

Figure (85)

Holy Island - Gene Frequencies for R B C Acid Phosphatase Types

	Holy Island group (a)	Holy Island Total	Mainland	Students
Pa	.364	.348	.313	.356
Pb	.591	.609	.650	.609
Pc	.045	.043	.037	.035

The gene values found in this study overlap the lower end of the Pa and Pc range and the upper end of the Pb range when compared with the results of Goedde (1970). The mainland and student samples are especially anomalous in this respect. Some significant differences are obtained in most of the chi-squared comparisons performed. The Pb gene is in the process of being increased on the island by its increased frequencies amongst the group (b) spouses when compared with group (a). This is a similar situation to the ABO blood group system mentioned earlier in this part.

The Red Blood Cell Isoenzyme Phosphoglucomutase

Spencer et alia (1964) demonstrated the genetic variability of the sub-types of this enzyme on starch gels. Later Hopkinson and Harris (1965) found that some of the faster bands were controlled by another gene locus and named by them PGM locus 2. However this study is confined to variation found at locus 1. Hopkinson and Harris (1965 and 1966) record distribution patterns for locus 1. Figure (86) shows two comparative results extracted from the above papers (for the English results) and from Goede (1970) (for the German result).

Figure (86)

Holy Island - Gene Frequencies for the R B C Phosphoglucomutase

Gene Locus 1

	Numbers	PGM_1^2 Gene
Hamburg	770	0.213
England	2115	0.235
Mainland	119	0.185
Holy Island group (a)	87	0.299
Holy Island Total	127	0.264

There is an excess of the PGM-2 gene amongst the Holy Island core population. This is in turn being lowered by the group (b) immigrants. The island results are amongst some of the highest 2 gene frequencies so far recorded. The phenotypes also display a great deal of variation but for the most part the island does not differ significantly from the other samples (see Figure (68)). It is not possible at this stage to demonstrate British heterogeneity of the PGM genes, or otherwise.

The Red Blood Cell Isoenzyme Adenylate Kinase

Fildes and Harris (1966) demonstrated starch gel electrophoretic variants of this enzyme. Rapley et alia (1967) have summarised the results for all populations tested. This has been expanded by Tills (1970b) (1971) and Goedde (1970). Extracted results are given in Figure (87).

Figure (87)

Holy Island - Results of the R B C Adenylate Kinase Isoenzyme

	Number	1-1	2-1	2-2	AK 2 gene
Hamburg (Goedde)	1090	91.1	8.7	0.2	.046
Irish (Tills)	789	93.7	6.3	0	.032
London (Harris)	1887	91.1	8.8	0.1	.045
Mainland (this study)	123	95.9	4.1	0	.021
Students (this study)	209	92.3	7.7	0	.039
Holy Island group(a)	88	92.0	6.8	1.2	.046
Holy Island Total	127	92.1	7.1	0.8	.044

These results show little variation on the whole. The 2 gene frequencies are lowest among the mainland series, whilst the island total seems to have lower AK 2 gene frequencies than the London sample. One of the islanders happens to be an AK 2-2 phenotype and this has greatly increased the 2 gene frequency on the island.

The Red Blood Cell Isoenzyme Phosphohexose Isomerase

Detter et alia (1968) found eight phenotype variants out of a sample of 3400. These were distributed amongst twenty individuals and eleven of these were type 3-1. This type predominates amongst Asian Indians. Variation in this country is rare and so it is not surprising that all the islanders tested showed the common phenotype.

The Red Blood Cell Isoenzyme Adenosine Deaminase

Spenser et alia (1968) and Hopkinson et alia (1969) first described this system. The results from the English population given in Figure (88) are in part from the above papers and in part from Goedde (1970), Lefevre and Niebuhr (1970) and Dissing and Knudsen (1970).

Figure (88)

Holy Island - Results of R B C Adenosine Deaminase

	Number	1-1	1-2	2-2	ADA 2 gene
Hamburg (Goedde)	861	87.5	12.2	0.3	.065
West Berlin (Lefevre)	500	88.6	11.2	0.2	.058
Denmark (Dissing)	1321	88.1	11.6	0.3	.061
London (Spencer)	1223	90.4	9.4	0.2	.049
Holy Island Total	127	75.6	21.3	3.1	.138

The 2 gene on the island is higher than any so far recorded from Western Europe. The frequency is greater than the results of Hopkinson (1969) for Asian Indians and is only matched by the results of Iraqi and Yemenite Jews (Szeinberg et alia 1971) and the Lapps (Eriksson 1971). In addition these two papers show that wide fluctuations can occur in the gene frequencies amongst small groups.

The chi-squared comparisons made in Figure (68) show that the island is significantly different to other West European series. These facts leave it open to speculation what has caused these high 2 gene frequencies on the island.

The Red Blood Cell Isoenzyme 6-Phosphogluconate Dehydrogenase

Fildes and Parr (1963) described genetic variants of this enzyme using starch gel electrophoresis. Type C is the rare and type A the common co-dominant allele. Large samples are reported by Parr and Fitch (1964) and Parr (1966). The material in Figure (89) is taken from Tills et alia (1970a).

Figure (89)

Holy Island - Results of R B C 6-Phosphogluconate Dehydrogenase Isoenzyme Variants

	Number	% CA	6-PGD gene C
Ireland (Tills)	789	2.8	.014
London (Parr)	4557	4.1	.021
Holy Island Total	122	3.3	.017

The frequency for the island fits in well with the results from Ireland and the large London sample of Parr. Statistical comparisons were not made but it is unlikely that significant differences exist.

The Red Blood Cell Isoenzyme Lactate Dehydrogenase

Boyer et alia (1963) and Nance et alia (1963) were the first to find electrophoretic variation among the sub-units of this enzyme. The incidence of European variation is very low (Davidson et alia 1965) and so the lack of variation in this small island sample is in accord with earlier observations.

The Red Blood Cell Isoenzyme Glucose-6-Phosphate Dehydrogenase

Electrophoretic variants were found by Boyer et alia (1962) and Kirkman and Hendrickson (1963) in negro populations. Since then many variants have been found (Giblett 1970). No electrophoretic variants were found in this sample and no other tests were undertaken.

The Phenyl-Thio-Carbamide Tasting Polymorphism

A tasting dimorphism with this chemical was first discovered by Fox (1932). Fuller elucidation of the genetic status of this trait was undertaken by Harris and Kalmus (1949) and considerable heterogeneity has been shown in this country (Sunderland 1966). The results for 'mainland schoolchildren' given in Figure (67) are from rural Northumberland whilst those in Figure (90) below are for North Northumberland (Wooler, Berwick and Seahouses) only. It is the North Northumberland samples that are used in the chi-squared tests in Figure (68); which shows statistically significant differences between the island and the mainland. The antimode for all the results is taken at solution 4.

Figure (90)

Holy Island : PTC Results

	Number	Nontasters	% nontasters
North Northumberland	79	17½	22.2
Holy Island group (a)	86	36½	42.4

Marked variations have been found for PTC gene frequencies in this country and although the island frequency of non-tasters is high it is not unique for Britain. The increased numbers of non-tasters amongst the group (a) inhabitants may merely reflect age changes. Kalmus and Trotter (1963) have demonstrated that taste sensitivity declines 0.0468 ± 0.0118 threshold units annually and as it occurs in this thesis the various comparison groups from the North were mainly schoolchildren. Thus it is possible that some of the uniqueness of the island may be due to the ageing population on the island. The total island sample is shown subdivided by age in Figure (91). No obvious age trends are demonstrated here,in fact

Figure (91)

Age Trends in PTC Tasting

Using the total Holy Island population whose ages are certainly known

Born;	NT	1	3	4	5	6	7	9	11	Total	% Non-tasters
1909 and before	5	6	1	1	3	3	6	11	3	39	32.1
1910-1924	3	9	4	2	1	2	10	9	4	44	38.6
1925 and after	4	6	5	0	0	0	6	9	6	36	41.7

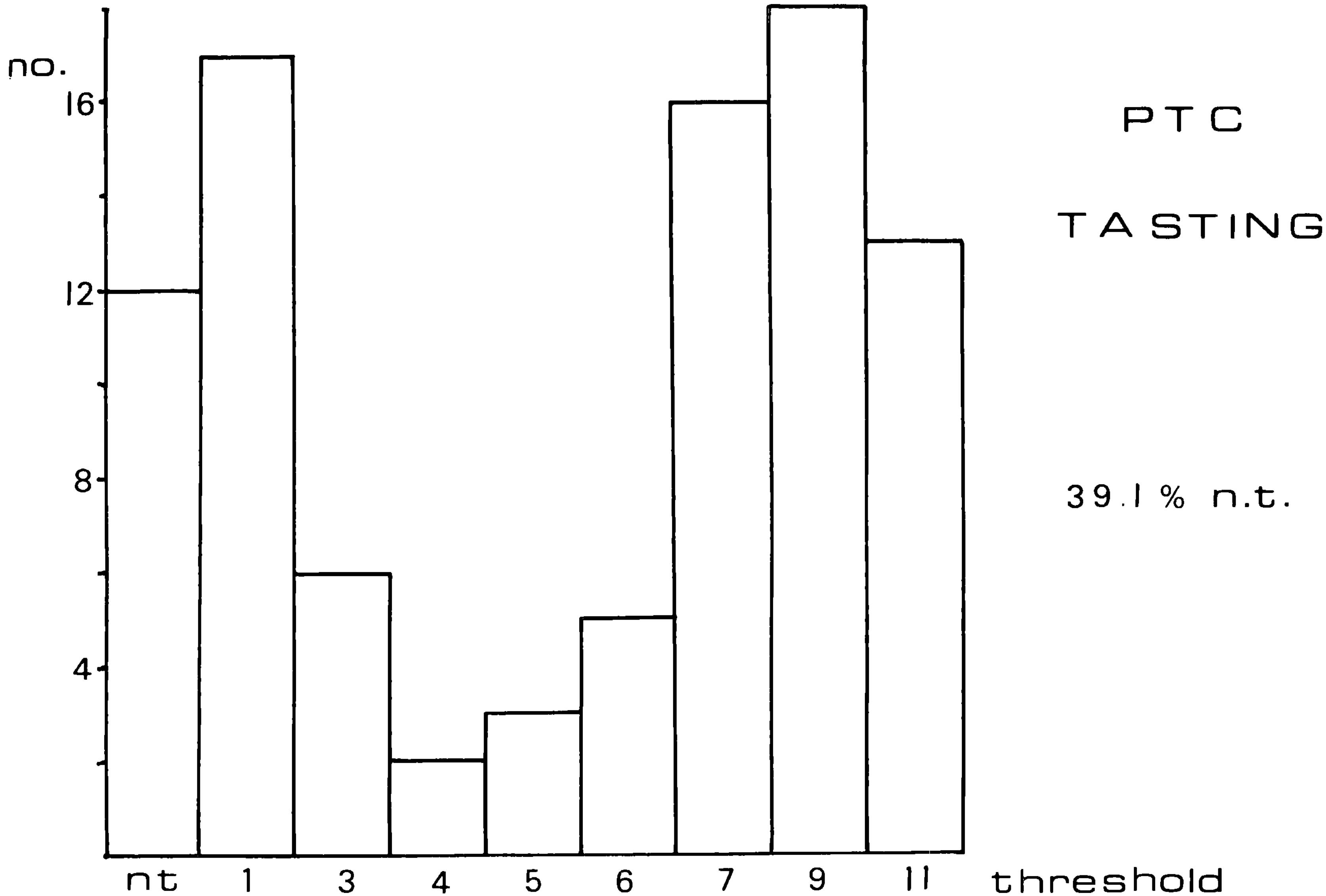
here the proportion of non-tasters (antimode 4) increases with age decrease rather than following the findings of Kalmus and Trotter (1963). Figure (92) shows the threshold distribution of a selected island sample; that is group (a) plus group (b) spouses who have children on the island. This is the group used later in the calculations of interrelationships. This figure shows that the antimode falls at solution 4.

Recent observations in Durham (Teasdale 1972) indicate that some of the minerals present in water may influence the tasting results,and this may be worth investigating further in the context of Holy Island.

Urinary Beta-Aminoisobutyric Acid Excretion

Urinary BAIB was detected in high quantities in the urine of some individuals by Crumpler et alia (1951). It was shown to be a polymorphism and restricted to man by Gartler (1961). The trait has been studied by McEvoy-Bowe (1962) and Harris (1953) and seems to be essentially due to an autosomal recessive gene producing high BAIB excretion in the homozygote. European and white American variability

Figure (92)



(Gartler 1961) is shown in Figure (93).

Figure (93)

Holy Island : High BAIB Excretion in some Populations

	Number	Number High Excretors	% High Excretors
Americans	504	45	8.9
Italians	792	55	6.9
English	345	35	10.1
Students (this study)	204	15	7.4
Holy Island Total	120	16	13.3

The difference between the students and the Holy Island series is not significant (Figure(68)). It seems therefore that the Holy Island population although it has a higher BAIB high excretion frequency varies little from what is known of the present distribution of the trait in the British Isles.

Anomalous Colour Vision

This trait has been extensively studied in this country by Vernon and Straker (1943) and Pickford (1951). There is no clear and consistent pattern of variation and the male frequency varies from 9.5% in the South-West of England to 5.4% in North-East Scotland. The aspects of natural selection that might operate on this trait have been discussed by Post (1962).

On Holy Island there is one male with the anomalous gene detected by the 24 plate Ishihara chart (1960),from his answers to plates 16 and 17 he is probably a protanope. This person has two sons and a daughter all tested and all normal and three childless brothers not tested.

His mother was born on the island but both her parents were from the mainland and so the gene has been introduced from Northumberland on this occasion. It is only possible to compare the island and the mainland statistically by weighting and under these circumstances the difference is significant,when compared to a mainland sample of schoolchildren. There is no difference in the female distribution on the island when compared to the mainland. The island shows an unexpectedly low frequency of colour blind people,probably due to the chance effects of population change over the centuries.

Discussion

Comments on the results presented so far in this chapter have been reserved,in the main,for a general discussion because the remarks to be included here apply to all the variables.

The island is genetically different from the mainland samples with which it has been compared. Of the 27 sets of variables,12 have demonstrated at least one significant difference,one more is just not significant at the 5% level of probability and comparisons were not properly possible with six other traits due to the absence of enough phenotypic variation.

How may these differences be explained? The populations under consideration are all very small. It is possible that the observed variations were due to sampling errors on the mainland. This is conceivable but unlikely,in that the island results consistently differ from the mainland,it is also unlikely that the mainland results should be consistently different from other samples in England,where they are available for comparison. Also the demographic history of the island makes it likely that the island would have a different population structure compared with the mainland. The relative contribution of different couples,the nature of mate selection and the fluctuation in the population size; all make it likely that the gene frequencies presented here are a transient phenomenon. The genetic pool will be likely to change with each generation and not remain in a constant Hardy-Weinberg equilibrium as 'characteristic' Holy Island gene frequencies.

Nevertheless calculation of the expected and observed Hardy-Weinberg values reveals that the expected heterogeneity is only manifest in two systems : Duffy and MN. The ABO system was tested ignoring the A subtypes and the rhesus chromosome complexes were omitted from the tests : this was because of the assumptions already made as to the distributions of genes in the rhesus complexes. It is difficult to know how to interpret these Hardy-Weinberg observations;* it could be taken as an indication that geographical comparisons are appropriate or that it is inappropriate to test such small samples with the expectation of revealing an equilibrium when there is good evidence to suggest that no such state should be expected (see chapter one). If this latter conclusion is correct then geographical comparisons become inappropriate. Unfortunately all the comparisons that are at present available for the United Kingdom are largely based on some geographical criteria. Many such studies are mentioned in this thesis. This is simply justified by the lack of any other suitable data. The distributional material has not proved at all helpful in explaining the Holy Island results. The inhabitants do not fit into any apparent pattern for the British Isles.

Studies on other small groups will be mentioned later,but generally speaking some unifactorial systems seem to vary from expected more frequently than others; the MNSs system is often the most variable

* It is possible that the Duffy and MN results are due to typing errors: this is less likely with the MN results due to controls.

and the rhesus system the least. In these terms the island sample matches other studies. Because of this it does not seem possible to compare the island with other published investigations because such small group variation is accounted for by genetic drift. Drift is a process of randomisation due to a variety of factors. The main randomising features of the Holy Island population have been mentioned above. In order to compare the island with another group, it would be necessary to define the demographic history of the group in as much detail as has been used in this thesis.

One method of effecting comparisons between two groups with differing demographic structures may be through the use of the value R; the coefficient of relationship. This term is defined early in the thesis. As used here it is the summated value of $(\frac{1}{2})^N$ where N is the number of steps interlinking two people through a common ancestor. The last chapter included the calculations for the relationship of the whole island. From this one may calculate a mean value for the whole island and in addition it is possible to compute mean values for various subdivisions of the island population. These subdivisions may be genetic phenotypes, quantitative values or any other type of variable which produces a set of population subdivisions.

In this context it is possible to find the mean values of R for the various unifactorial phenotypes and to examine the possibility that interrelationships exert a differential effect upon the results. Some genetic systems may have their frequencies due to many interrelated individuals existing with that phenotype in the living island population. This has not been computed yet for the whole range of variables but a few results are available. Figure (94) gives the results for relationship data on the PTC threshold material and the Duffy blood

Figure (94)

Unifactorial Traits and the Coefficient of Relationship

PTC Threshold	Numbers per group	Summated R	z	x	r	r/lowest	r/Tr
NT	11	0.9543	55	50	.0091	4.6	.43
1	16	2.5485	120	94	.0119	6.0	.57
3	9	0.0886	36	9	.0020	0	.09
6	3	0.0156	3	2	.0031	1.6	.15
7	14	2.5975	91	67	.0164	8.2	.78
9	20	3.8308	190	121	.0123	6.2	.59
11	8	1.2791	28	16	.0291	14.6	1.39
Duffy Blood Groups							
(a)-(b)- , (a)-(b)+	27	5.1358	351	128	.0107	0	.51
(a)+(b)-	11	1.2024	55	57	.0107	0	.51
(a)+(b)+	53	36.3148	1378	1072	.0148	1.4	.70

z = n(n-1)/2

x = the total number of relationships

r = R/z+x

Tr is the total population value of r calculated earlier group system. These are some preliminary calculations and the true summated R values for each pair of individuals has not been calculated; all the N values have been added together for each group and so in order to find a value for each subgroup that is comparable,the summated values of R have been divided by the total number of relationships x as well as the total number of possible pairs of values z. The value z is the progression of n(n-1)/2 ; the expansion of a triangular matrix. The value obtained in this fashion (r),is not a true mean relationship but a figure that reflects the total group relationship. The PTC relationships vary within a range of 14 times from the lowest to the greatest value whilst the Duffy phenotypes vary much less. The value of R for the total population (Tr) is also compared with the subgroup values of r.

It seems possible that relationships have an influence on the island results but what this is,in detail,will not be clear until all the variables have been examined in this manner. This aspect of the work has wider implications in that a good deal of data is being collected which involves related individuals and although it may not be possible to contrast such material geographically,it might be possible to evaluate the relatedness aspect of such studies.

Collation

Part (k) is a long section which presents the results for the unifactorial traits. First of all the results are given as a table using the subdivisions mentioned in part (i). All,except group (c), are mentioned as phenotype numbers and percentages. Two main sets of controls are employed; a small donor sample from the mainland

and a larger student sample from Durham. This is followed by a table of chi-squared test results which compare the Holy Island sample with the various control groups.

A series of sub-parts then follows and each gives details of the variables and mentions the results. Additional data are also included from other sources. Some comments are made individually on each variable but the major discussion is reserved for the end section of this part. The ABO gene frequencies are calculated and rounded off after Mourant (1954) whilst the rhesus chromosome types are simply assumed from the commonest European types as recorded in Race and Sanger (1968). The MNSs system is presented as genes and phenotype complexes rather than chromosome types. These three red cell systems present problems of gene or chromosome estimations and results obtained by methods other than gene counting should only be thought of as values,which in a small interrelated population are quite likely inaccurate because of the unknown and estimated genes involved. The other blood group systems,serum types and enzymes are all given as phenotype and gene frequencies which are mostly calculated by the gene counting method. Exceptions to this are the P,Lutheran,secretor,Ag,PTC and BAIB genes whose gene frequencies are computed from the homozygous combinations. In all cases it is possible to argue that the comparative material is inappropriate and indeed that it is impossible to provide suitable material to compare with the island group. Some of the random material which acts in this capacity are more appropriate than others. The mainland series of about 140 blood donors was selected for the ABO and rr type and so comparisons involving these traits are of little value.

Despite all these reservations it is possible to see that there are many differences between the Holy Island population and those groups with which it has been compared. This is dealt with in the final discussion towards the end of this part. The results of the Hardy-Weinberg computations are also mentioned here. These suggest that the gene systems are mostly in equilibrium despite the data and conclusions presented in chapter one. This may suggest that the equilibrium method is of itself an insensitive measure and the establishment of non-significant differences in a population between the observed and expected results does not necessarily mean that a small group is in equilibrium. This view is also discussed by Neel (1965).

The discussion continues with a consideration of how comparisons may be effected between populations of differing history and demography. One possibility which is explored here is the use of genetic inter-relationships. A simple formulation of R, the coefficient of relationship, and a crude mode of calculation of group relatedness, has been adopted to provide some initial results. This method of analysis was introduced in part (g) and is continued in part (t). Quite considerable variations are found between the various values found for R. This significance of this mode of analysis is not understood. The method apparently provides a means of analysing many different types of attribute by the same means.

Part (1)

Multifactorial Traits

This part includes the results of the skin colour studies and the analysis of the dermatoglyphic results.

Skin Reflectance Studies *

This trait is now established as polygenic in type (Harrison and Owen 1964). Not all the island inhabitants had skin reflectance values recorded from them for technical reasons. Also only three filters were used; Ilford 601,605 and 609. These correspond to the wavelengths 425,545 and 685 mmu. The student sample from the North of England is included in the results in Figure (95). This latter series was tested with the same EEL photometer used on the native island population.

Figure (95)

Skin Colour for the Holy Island Population

	601	sd	605	sd	609	sd	Total Tested
Holy Island groups (a) + (b)	34.4	5.0	38.9	4.5	64.7	3.8	90
Holy Island Total	33.8	5.2	39.1	4.4	63.4	3.7	104
Durham Student Series	31.4	4.9	35.7	4.8	61.8	3.3	147

* The EEL reflectance head was placed on the inner aspect of the upper arm and the results were recorded against a white standard ($MgCO_3$) block,set as 100% reflection.

The results in Figure (95) indicate a lighter element in the reflectance values of the group (a) plus (b) inhabitants. This amounts to about 2% when compared with the Durham students. This may be due to the age distribution in the sample : the Holy Island group (a) are by far the oldest of the above categories. Figure (96) shows the influence of age on the reflectance values. An age effect exists on the island with the older groups being darker than the younger group. The result is contrary to what might be expected and is difficult to explain satisfactorily.

Figure (96)

Skin Colour : Mean Values for Different Age Groups

	601	605	609	Total Tested
born 1904 and before	33.2	38.3	62.4	34
born 1905 to 1924	33.4	40.1	62.0	34
born 1925 and after	35.6	40.7	64.3	32

The interrelationships that exist on the island may account for some of these differences. This aspect of the skin colour results has not been explored. The various intergroup statistical tests were all not significant,possibly partly due to the small sample sizes involved.

Dermatoglyphic Studies

This series of traits have quite well defined modes of inheritance (Holt 1968) ; with the exception of the appearance of the c-triradius all are polygenic in type.

Many difficulties were experienced in obtaining satisfactory impressions of the palms of the older islanders,especially the fishermen. It was decided mainly to study the results of palmar variability. However some simple finger pattern types were readable from digits 2 to 5 and these are recorded in Figure (97).

The palmar patterns were assessed according to the methods of Cummins and Midlo (1943). The author realises that this is no guarantee that similar patterns will be correctly named by all workers and it is possible that many of the different results presented here are due to a discrepancy in interpretation.

Figure (97) gives the results of the finger patterns for digits two to five,whilst Figure (98) aggregates these values and compares them with data from Berkshire and Oxfordshire schoolchildren collected by Coope (1965). The two groups are significantly different; Holy Island has fewer arches and more whorls than the Midlands sample. Less weight can be placed on the results from the island as they are deficient in thumb print data as well as the complete data from the other digits.

Figure (99) gives the hypothenar pattern types for the Midlands and Holy Island. Those pattern combinations not found in the island sample,but present in the Coope results,are aggregated as 'others' in the table. The chi-squared test of A^u versus L^r versus 'the rest' produces only one significant result : for the female right hand. But the 2 x 2 comparison of A^u versus the rest of the patterns,gives results which are all insignificant at the 5% level of probability. It seems likely therefore that the heterogeneity shown in the right female palm is due to an excess of L^r patterns in this group. All the other results are too infrequent for comparisons to be made but a glance at Figure (102) shows wide differences apparently in existance.

Figure (97)

Holy Island : Finger Pattern Types for the Total Population

	R2	R3	R4	R5	L2	L3	L4	L5	(Digits)
Group (a) Male									
Arch	2	2	0	0	2	2	0	0	
Loop	26	31	21	34	28	36	29	38	
Whorl	8	10	20	5	11	4	10	4	
Group (a) Female									
Arch	1	0	1	0	0	0	1	2	
Loop	16	24	15	20	14	28	22	16	
Whorl	8	7	14	8	8	4	6	5	
Group (b) Male									
Arch	0	0	0	0	0	0	0	0	
Loop	2	4	1	4	3	2	3	3	
Whorl	2	0	2	1	1	2	1	1	
Group (b) Female									
Arch	2	0	0	0	3	3	1	0	
Loop	9	14	8	11	9	13	9	10	
Whorl	2	2	8	2	3	1	6	2	
Group (c) Male									
Arch	0	0	0	0	0	1	0	0	
Loop	6	6	3	2	5	5	4	4	
Whorl	1	1	3	1	2	1	3	0	
Group (c) Female									
Arch	2	1	1	0	2	2	0	0	
Loop	4	8	6	5	4	6	6	7	
Whorl	3	1	3	1	3	1	3	2	

Figure (98)

Total Finger Pattern Types

Berkshire Rural

	Male	Female
Arches	161 (4.6)	323 (8.4)
Loops	2480 (71.3)	2740 (71.4)
Whorls	839 (24.1)	777 (20.2)
Totals	3480	3840

North Oxfordshire Rural

Arches	101 (4.4)	184 (7.7)
Loops	1568 (68.5)	1723 (72.1)
Whorls	621 (27.1)	483 (20.2)
Totals	2290	2390

Holy Island

	Group (a) Males	Group (b) Males	Group (a) Female	Group (b) Female
Arches	8 (2.5)	0	5 (2.3)	9 (7.6)
Loops	243 (75.2)	22 (68.8)	155 (70.4)	83 (70.4)
Whorls	72 (22.3)	10 (31.2)	60 (27.3)	26 (22.0)
Totals	323	32	220	118

Holy Island Total

	Male	Female
Arches	9 (2.2)	22 (5.4)
Loops	300 (74.5)	284 (69.4)
Whorls	94 (23.3)	103 (25.2)
Totals	403	409

Chi-squared tests between North Oxfordshire and Holy Island Total are as follows ; Males 7.6 ,significant at P. of 1-2½% and Females 6.8 , significant at P. of 2½-5%.

Figure (99)

Hypothenar Pattern Types

Oxfordshire and Berkshire (extracted from Coope 1965)

	Male Right	Male Left	Female Right	Female Left
A^u	104 (59.4)	104 (59.4)	87 (47.1)	81 (43.9)
$L^r(+L^r/A^u)$	35 (20.0)	33 (18.9)	37 (20.0)	42 (22.7)
L^u	6 (3.4)	9 (5.1)	9 (4.9)	5 (2.7)
W^s	2 (1.2)	1 (0.6)	3 (1.6)	1 (0.5)
L^c	1 (0.6)	0	6 (3.3)	0
T^r	0	0	1 (0.5)	1 (0.5)
T^u	0	0	0	0
L^u/L^u	0	1 (0.6)	1 (0.5)	1 (0.5)
L^u/A^u	0	3 (1.7)	1 (0.5)	3 (1.6)
L^r/L^u	0	0	0	0
Others *	27	24	40	51
Total	175	175	185	185

* Not in the Holy Island sample but in Coope (1965)

Total Holy Island Sample

	Male Right	Male Left	Female Right	Female Left
A^u	45 (72.6)	44 (72.2)	37 (58.7)	34 (55.7)
L^r	11 (17.8)	11 (18.0)	17 (27.0)	14 (23.0)
L^u	2 (3.2)	2 (3.3)	3 (4.7)	5 (8.2)
W^s	2 (3.2)	1 (1.6)	2 (3.2)	5 (8.2)
L^c	0	0	2 (3.2)	2 (3.3)
T^r	0	0	1 (1.6)	0
T^u	0	0	1 (1.6)	0
L^u/L^u	0	1 (1.6)	0	0
L^u/A^u	2 (3.2)	0	0	0
L^r/L^u	0	2 (3.3)	0	1 (1.6)
Total	62	61	63	61

Chi-squared tests between A^u, L^r and the rest and the two regions; Male Right is NS, Male Left is NS, Female Right is 8.2, significant at a probability of 1-2½%, Female Left is NS.

Figure (100) gives the results of the thenar pattern types again comparing the Coope results with the present study. The only statistical comparison made is that of open fields versus all other pattern types and this shows no significant differences between the groups. Nevertheless there are fewer open fields in the Holy Island population than in the South Midlands sample.

Figure (101) records the position of the axial or t triradius. Again the Midlands and Holy Island are compared. Here differences exist in three out of four comparisons. Figures (102),(103) and (104) give the rest of the available palm print results. With the attributes mentioned here,no British comparison material is readily available and so the tables simply record the data. One exception to this is the a-b ridge count from the palm. This ridge count is similar to Fang (1950) with only one ridge difference. The standard deviations have been calculated ignoring the usual skew distribution of dermatoglyphic material. The standard deviations are much larger for the small island sample than the quoted material. The combined ridge counts are lower on the island than for London (Fang 1950). Similarly the Coope (1965) material for the South Midlands has higher combined ridge counts.

It is difficult to interpret the results from Holy Island when little useful comparative material exists. It could be said that the heterogeneity found by Coope in the finger ridge counts is also to be found in other aspects of dermatoglyphic studies or alternatively that the available material merely gives this impression due to the small size of the population. In addition to this it is known that palmar ridge counts have higher degrees of variance than finger ridge counts and also that qualitative traits vary more than quantitative

Figure (100)

Thenar Pattern Types

Oxfordshire and Berkshire (extracted from Coope 1965)

	Males Right	Males Left	Females Right	Females Left
Open fields	159 (90.8)	152 (86.9)	165 (88.7)	161 (88.5)
Loops	12 (6.9)	9 (5.1)	8 (4.3)	13 (7.1)
Whorls	0	2 (1.1)	0	1 (0.6)
Vestiges	4 (2.3)	12 (6.9)	13 (7.0)	7 (3.8)
Totals	175	175	186	182

Total Holy Island Population

	Males Right	Males Left	Females Right	Females Left
Open Fields	51 (87.9)	48 (78.7)	55 (91.7)	53 (88.3)
Loops	3 (5.1)	9 (14.7)	1 (1.7)	1 (1.7)
Whorls	2 (3.5)	2 (3.3)	0	1 (1.7)
Vestiges	2 (3.5)	2 (3.3)	4 (6.6)	5 (8.3)
Totals	58	61	60	60

Chi-squared test results for open fields versus all other pattern types,

Males Right	NS
Males Left	NS
Females Right	NS
Females Left	NS

Figure (101)

Position of Axial Triradii

Oxfordshire and Berkshire (extracted from Coope 1965)

	Males Right	Males Left	Females Right	Females Left
t	142 (84.5)	138 (81.7)	126 (73.7)	123 (69.9)
t'	21 (12.5)	24 (14.2)	33 (19.3)	43 (24.4)
t"	5 (3.0)	7 (4.1)	12 (7.0)	10 (5.7)
Total	168	169	171	176

Total Holy Island Population

t	58 (93.6)	59 (96.8)	55 (87.3)	57 (90.5)
t'	3 (4.8)	1 (1.6)	7 (11.1)	4 (6.3)
t"	1 (1.6)	1 (1.6)	1 (1.6)	2 (3.2)
Total	62	61	63	63

Chi-squared test results for t versus t' plus t" where possible;

Females right = 4.92 ,significant P. is 2½-5%

Females left =10.67 ,significant P. is 0.1-½%

Figure (102)

a-b Ridge Counts

London (extracted from Fang 1950)

	Right	Left
Males	41.1 (5.5)	41.9 (5.4)
Females	40.9 (5.4)	42.0 (4.9)

Total Holy Island Population

	Right	Left
Males	40.7 (7.2)	40.4 (5.0)
Females	39.3 (5.7)	39.2 (6.1)

Standard deviations are given in brackets

Combined Left and Right Ridge Counts a-b

	Males	Females
London (Fang 1950)	83.01	83.04
Midlands (Coope 1965)	84.84	83.63
Holy Island Total	81.13	78.43

Other Ridge Counts

Holy Island Total	b-c	57.91 males	52.78 females
	c-d	72.40 males	69.31 females
	a-d	208.33 males	199.11 females

Figure (103)

atd Angles in the Holy Island Population

	Mean atd	N	Mean at'd	N	Mean at"d	N
Left Males	39.85	59	39.00	1	66.00	1
Right Males	40.78	58	50.83	3	68.00	1
Left Females	38.79	58	53.83	3	79.80	2
Right Females	40.13	52	48.50	9	68.50	1

Figure (104)

Missing c-Triradii in the Holy Island Population

	Missing	N	Percentages
Left Males	3	61	4.9
Right Males	2	62	3.2
Left Females	4	63	6.4
Right Females	5	63	7.9

ones. The small Holy Island sample is not likely to be able to resolve such possible sources of variability and the dermatoglyphic results given here are, in the main, without many comparisons and without comment.

Collation

Part (l) has dealt with two traits which are principally controlled in a multifactorial fashion. These are skin reflectance values and dermatoglyphic traits of the hand. The studies have not helped very much in illuminating the significance of the variability of the Holy Island population. However the variability of these traits is less likely to be influenced by the island's dynamic demography than the unifactorially inherited traits. This may be inferred from the concept of many genes of small effect working additively, which increase the total number of genes involved even in small populations. This leads to an increased stability of genetic effect. The size of many of the standard deviations rather argues against this. Because of the apparently heterogenous nature of the samples and because of the contorted Gaussian distributions involved sets of data cannot be properly compared. In addition to this the lack of nearby samples for comparison again makes the apparent differences on Holy Island less significant.

Despite all the disadvantages of these two groups of attributes they appear to confirm differences found also amongst the unifactorial variables in part (k) and the other population variables in part (m). At this simplest of levels the traits once more confirm that the island population is unique.

Part (m)

Population Variables of Doubtful Inheritance

The modes of inheritance of the traits included in this section have either not been properly ascertained or disputed in some way. This is a long part and is divided into the following four sub-parts :

(i) Joint Sense and Handedness.

(ii) A Note on the Ability to Smell Potassium Cyanide.

(iii) The Ability to Roll the Tongue.

(iv) The Variation in Finger Length.

A brief final collation attempts to bring together a few similar themes from each of the four sub-parts.

(i)

Joint Sense and Handedness

Since Lutz (1908) no work has been published on joint sense that includes results from this country. It was decided to include some regional data in order to rectify this.

Joint sense is the phrase used to describe the different positions to which the limbs are put at various joints when performing certain specific actions; in this case at the shoulder,elbow,wrist and thumb joints. Handedness,however,is the preferential use of one particular arm or hand in a wide variety of familiar actions. Handedness can be subdivided at various joints depending upon a specific action, but this is not done here.

Methods

Each person was asked if he considered himself right (R) or left (L) handed. If an unequivocal response was elicited this was noted,if not then the response was ignored.

In order to obtain joint sense preferences at the shoulder, each person was asked to approximate the ear and the shoulder as closely as possible. Some islanders could not do this satisfactorily due to a variety of musculo-cutaneous and skeletal defects. Normally however the response R or L was noted to the question "Which shoulder feels most comfortable?". Repetition eliminated most of the initially ambiguous responses.

The subject was then asked to fold arms and the uppermost elbow was noted,similarly at the wrist the uppermost hand used whilst clapping was noted and the uppermost thumb noted when the fingers were interlocked. All such responses were double checked but no discrepancies were found.

In this way the two alternatives R or L were observed at four joint levels; the elbow,wrist,thumb and shoulder. This allows sixteen possible combinations which have been numbered arbitarily in Figure (105).

The Populations Examined

The entire Holy Island sample was used along with several other groups from this country for comparison. The North of England student series from Durham University was called control one. This group numbers about 245 and the vast majority are aged 17 to 24. Some of this group were asked about their own hand preferences. The next series (control two) is a regional sample collected from a secondary school at Sedgefield and one at Middlesborough,both in County Durham. This group was collected by university students under the direction of R.J.Mitchell. The third group (control three) is random material extracted from about 60 families collected in South London (Sillitoe 1971).

The Results

All four sets of data are given in Figure (106). Those people omitted from the Holy Island series either gave equivocal results or could not perform the tests satisfactorily. Figure (107) shows all the results expressed as a single joint combination; hand clasping for the thumb and so on. The results in Figure (106) allow the distribution of other joint combinations to be computed.

Figure (105)

Joint Sense Combinations used in this Study

Shoulder	Elbow	Wrist	Thumb	Code
L	L	L	L	1
R	R	R	R	2
R	L	R	R	3
R	R	R	L	4
L	R	R	R	5
R	R	L	R	6
L	R	L	R	7
R	L	R	L	8
R	L	L	R	9
R	R	L	L	10
L	L	R	R	11
L	R	R	L	12
R	L	L	L	13
L	L	L	R	14
L	R	L	L	15
L	L	R	L	16

Figure (106)

Handedness Results

Combination	Holy Island						Control 1						Control 2		Control 3	
	Males	%	Females	%	Total	%	Males	%	Females	%	Total	%	Total	%	Total	%
1	3	5.0	1	1.6	4	3.2	10	6.7	6	6.3	16	6.6	2	1.5	3	3.7
2	5	8.3	8	12.5	13	10.5	14	9.4	6	6.3	19	7.8	17	13.1	4	4.9
3	10	16.7	10	15.6	20	16.1	16	10.7	7	7.4	24	9.8	24	18.4	11	13.6
4	2	3.3	7	10.9	9	7.3	17	11.4	12	12.6	29	11.9	10	7.7	7	8.6
5	5	8.3	3	4.7	8	6.5	4	2.7	4	4.2	8	3.3	8	6.2	5	6.2
6	2	3.3	0		2	1.6	4	2.7	2	2.1	6	2.5	3	2.3	0	
7	1	1.7	1	1.6	2	1.6	3	2.0	5	5.3	8	3.3	6	4.6	1	1.2
8	8	13.3	7	10.9	15	12.1	13	8.7	11	11.6	24	9.8	14	10.8	24	29.6
9	2	3.3	1	1.6	3	2.4	7	4.7	6	6.3	13	5.3	4	3.1	2	2.5
10	4	6.7	1	1.6	5	4.1	13	8.7	6	6.3	19	7.8	2	1.5	2	2.5
11	6	10.0	8	12.5	14	11.3	10	6.7	5	5.3	15	6.1	12	9.2	5	6.2
12	1	1.7	4	6.2	5	4.0	3	2.0	2	2.1	5	2.0	7	5.4	2	2.5
13	2	3.3	3	4.7	5	4.0	17	11.4	9	9.5	26	10.7	10	7.7	3	3.7
14	2	3.3	0		2	1.6	7	4.7	6	6.3	13	5.3	4	3.1	6	7.4
15	0		3	4.7	3	2.4	3	2.0	6	6.3	9	3.7	1	0.8	3	3.7
16	7	11.7	7	10.9	14	11.3	8	5.4	2	2.1	10	4.1	6	4.6	3	3.7
Totals	60		64		124		149		95		244		130		81	

Figure (107)

Results for Single Joint Senses

	Holy Island		Control 1		Control 2		Control 3	
	N	%	N	%	N	%	N	%
Hand Clasping								
L	60	48.4	137	56.3	54	41.5	38	42.2
R	64	51.6	106	43.7	76	58.5	52	57.8
Wrist Use								
L	26	21.0	110	45.3	32	24.6	29	23.0
R	98	79.0	133	54.7	98	75.4	93	73.8
							(+ 4 equivocal)	
Elbow Use								
L	77	62.1	140	57.6	77	59.2	86	31.7
R	47	37.9	103	42.4	53	40.8	40	68.3
Shoulder Use								
L	52	41.9	84	34.6	46	35.4	55	61.1
R	72	58.1	159	65.4	84	64.6	30	33.3
							(+ 5 equivocal)	

Discussion

No sex differences were found in any combination involving the Holy Island results and those of the Durham University Sudent series. A chi-squared comparison of Holy Island and the control one results is made possible by pooling the following combinations : 1+2,5+6+7, 9+10 and 14+15. The calculated value is 24.96 at ten degrees of freedom,which is significant at the 1-2½% level of probability.

In order to try and maximise intercategory differences the shoulder joint choice - the least satisfactory because of its subjectivity - may be omitted. This enables the reduced combinations to be calculated and these are seen in Figure (108). Comparisons of the total group on the island with control one gives the significant chi-squared value of 26.0 (pooling the two combinations RLR and RLL). The probability varies between 0.5 and 0.1%. The greatest differences between the samples lie in categories LLL and LRR. Many other subdivisions of the joint combinations can be obtained from Figure (108) but most are not large enough to be utilised statistically,in addition such differences are best demonstrated when the joint levels are examined individually.

Figure (109) gives the results at single joints,there is no significant sex difference in this series. Intergroup comparisons yield a complex pattern of differences and similarities .The results underlined in Figure (109) are significant at least to the 5% level of probability. These figures indicate the differences also found in the combined joint sense categories above,are in fact due to differences at the wrist joint in the case of Holy Island versus control one and differences found in the other series are revealed when they are compared with each other.

Figure (108)

Joint Combinations at Three Joint Levels

			Holy Island Total		Control 1	
Elbow	Wrist	Thumb	N	%	N	%.
L	L	L	9	7.3	42	17.3
L	L	R	5	4.0	26	10.7
L	R	R	34	27.4	39	16.0
L	R	L	29	23.4	33	13.6
R	L	R	4	3.2	14	5.8
R	L	L	8	6.5	28	11.5
R	R	L	14	11.3	34	14.0
R	R	R	21	16.9	27	11.1
Totals			124		243	

Figure (109)

Holy Island : Comparisons at Single Joint Levels by χ^2-test results

	Holy Island v. Control 1	Holy Island v. Control 2	Control 1 v. Control 3	Control 1 v. Control 2	Holy Island v. Control 3	Control 2 v. Control 3
Shoulder	NS	NS	NS	NS	NS	17.81
Elbow	NS	NS	3.93	NS	NS	NS
Wrist	18.00	NS	15.99	15.34	NS	NS
Thumb	NS	NS	NS	7.50	NS	NS

Figure (110) gives the results at each joint by age group; it also includes an extra series of results which have had the L hand preferenced individuals extracted. The chi-squared comparisons show no significant differences at the 5% level of probability (using L+R handed people, lumping was required in the case of the wrist and shoulder joints), nevertheless there are slight age trends at the wrist and shoulder joints.

Figure (111) shows the pattern of results for hand preferences and joint sense. The chi-squared test only reveals a difference in the pooled (Holy Island plus control one) results for the wrist joint (chi-squared value is 21.4 which at one degree of freedom is significant at a probability of less than 0.1). In view of the heterogeneity demonstrated at the wrist joint in Figure (109) it is difficult to know what is being demonstrated here. Even so, it seems likely that the differences in Figure (109) are in part due to the significant disproportionate distribution of the left-handed individuals seen in Figure (111).

Figure (110)

Age and Joint Sense : with and without Left Handed People

Born :		Before 1900		Before 1910		Before 1924		After 1924	
Total Hand Clasping	R	9	45.0%	21	53.9%	16	57.1%	18	47.4%
	L	11	55.0%	18	46.1%	12	42.9%	20	52.6%
		20		39		28		38	
Hand Clasping Right Handers only	R	9	47.4%	18	52.9%	15	55.6%	17	51.5%
	L	10	52.6%	16	47.1%	12	44.4%	16	48.5%
		19		34		27		33	
Total Wrist Use	R	18	90.0%	32	82.1%	23	82.1%	26	68.4%
	L	2	10.0%	7	17.9%	5	17.9%	12	31.6%
		20		39		28		38	
Wrist Use Right Handers only	R	18	94.7%	31	91.2%	22	81.5%	25	75.8%
	L	1	5.3%	3	8.8%	5	18.5%	8	24.2%
		19		34		27		33	

Figure (110) continued

		Before 1900		Before 1910		Before 1924		After 1924	
Total Arm Folding	R	8	40.0%	17	43.6%	12	42.9%	11	28.9%
	L	12	60.0%	22	56.4%	16	57.1%	27	71.1%
		20		39		28		38	
Arm Folding Right									
Handers only	R	7	36.8%	16	47.1%	12	44.4%	10	30.3%
	L	12	63.2%	18	52.9%	15	55.6%	23	69.7%
		19		34		27		33	
Total Shoulder	R	16	80.0%	22	56.4%	16	57.1%	19	50.0%
Use	L	4	20.0%	17	43.6%	12	42.9%	19	50.0%
		20		39		28		38	
Shoulder Use Right									
Handers only	R	16	84.2%	20	58.8%	16	59.3%	15	45.5%
	L	3	15.8%	14	41.2%	11	40.7%	18	54.5%
		19		34		27		33	

R = Right Hand Preference

L = Left Hand Preference

Figure (111)

Holy Island : Handedness with Joint Use

	Holy Island			Control 1		
	R	L	%L	R	L	%L
Shoulder Use						
R Preference	69	5	7.2	48	6	12.5
L Preference	44	6	13.6	40	5	12.5
Arm Folding						
R Uppermost	44	3	6.8	40	7	17.5
L Uppermost	69	8	11.6	48	4	8.3
Wrist Use						
R Uppermost	95	3	3.2	49	2	4.1
L Uppermost	18	8	44.4	39	9	23.1
Hand Clasping						
R Thumb Uppermost	59	5	8.5	34	3	8.8
L Thumb Uppermost	54	6	11.1	54	8	14.8

R = right handed L = left handed %L are the proportions of each left handed person with a hundred right handed people at the same joint preference.

Comparative Literature

Collins (1961) reports on a large student series from which it is possible to extract data for single joint levels;

					Total
Shoulder(excluding 'ambi.types')	L	149	R	301	450
Elbow	L	399	R	461	860
Wrist	L	233	R	627	860
Thumb	L	450	R	410	860

Comparisons with the Holy Island and other series again reveals a complex pattern of results; all are significantly different from the Collins (1961) material at the elbow joint and control 1 is also different at the wrist and control 2 at the thumb. Other material is included on the subsequent tables for hand clasping and arm folding.

Figure (112) summarises the results of studies on Europeans, on arm folding and hand clasping. The results with the mark *** are those results statistically significant at a probability of less than 0.1% when those groups are compared to the total Holy Island series. All the rest of the listed results are not significantly different from the Holy Island group up to the 5% level of probability.

Discussion - Hand Clasping

Two points emerge from this material : firstly there is no particular Caucasian distribution. The variation in this country is similar to the European variation. Secondly the world distribution (not given here) such as is available,differs very little from the results given in Figure (112). Age may have an effect on the distribution and it is noteworthy that the North Greek sample has the highest frequencies of R hand claspers and is also the youngest sample.

Figure (112)

Caucasian Groups : Mixed Sexes and Ages

Hand Clasping and Arm Folding

Population	Author	Sample Size	Right *** % Claspers/ Folders	Ages
Hand Clasping				
Brazilian Whites	Freire-Maia(1958)	1566	55.2	All ages
Spaniards	Pons (1961)	486	52.1	All ages
North Greeks	Pelecanos (1968)	2144	81.3 ***	8 -12
Russians	Freire-Maia (1965)	58	56.9	All ages
Swedes	Beckman (1962)	981	52.1	All ages
Australian Whites	Lai (1965)	207	49.3	All ages
American Whites	Collins (1961)	860	48.2	20-21
American Whites	Weiner (1932)	240	55.4	All ages
American Whites	Downey (1926)	1581	51.2	All ages
Aberdonians	Lutz (1908)	426	59.2	All ages
Holy Island)		124	51.6	All ages
Control 1)	Present	243	43.6	20-21
Control 2)	Study	130	58.5	11-16
Control 3)		90	57.8	All ages
Arm Folding				
Brazilian Whites	Quelce-Salgado	1605	41.4	All ages
North Greeks	Pelecanos (1968)	2144	45.5	8 -12
Russians	Freire-Maia (1965)	57	91.3 ***	All ages
Swedes	Beckman (1962)	981	46.6	All ages
American Whites	Collins (1961)	860	53.6	20-21
American Whites	Weiner (1932)	206	45.6	All ages
Holy Island)		124	37.9	All ages
Control 1)	Present	243	42.4	20-21
Control 2)	Study	130	40.8	11-16
Control 3)		126	68.3	All ages

*** see text

The results are apparently not altered by other enviromental manifestations. Hand preferences are not influenced by hand clasping types. It is tempting to postulate that the distribution of all hand clasping results are entirely random. This would explain why some differences were of a significant type and others not. Any genetic effect could be supplanted by diversification and randomisation in early life,if there were any genetic basis to the whole concept. Hand clasping and the other joint preferences tend,by their nature, to provide an artificially exact measure of population variability : everyone must put one thumb or the other uppermost. Although parental types do affect those of the offspring,there is no specific reason to suppose that this is an inherited affectation.

- Other Joints

The wrist joint has a significant association with hand preferences (unlike the other joints tested). This fact is substantiated by Collins (1961) who provides the results in Figure (113).

Figure (113)

The Influence of Handedness on Wrist Use

	R Handed	L Handed
R wrist uppermost	281	20
L wrist uppermost	58	62

Calculated chi-squared value is 110.7 for 1 degree of Freedom. This is a highly significant result with the probability of less than 0.1%.

If one accepts a hypothesis of minimum genetic control then the significant differences between the wrist joint results for Holy Island and control one are probably due to chance. The effect of these results is to alter the tests of significance when the joint combinations are examined. In other words the differences from joint to joint,in the same individual reflect the random differences that occur at any single joint level.

The other comments about single joint levels are the same as for hand clasping; the ageing effect is more marked at the wrist joint than the rest. It is difficult to know how to interpret this evidence; perhaps wrist movements become more restricted with age than the other joints involved and perhaps this restriction does not randomly affect either wrist.

- Joint Combinations

It is difficult to assess the differences in the various series presented here,partly due to the complexity of the problem and partly due to the lack of substantial comparative material. In each case the chi-squared test results only reflect the differences at each specific joint and not integral variation in the sets of joint combinations themselves. Sex,regional and age differences all suffer from the small sample sizes due to the numerous combinations and also to the fact that the combinations will have a higher chance of reflecting the single joint differences.

Conclusions

Joint sense combinations prove to be an unwieldy tool in anthropological research without very large samples,not a feature of this study. The single joint comparisons,on the other hand,although presenting occasional variation,are not heterogenous in a meaningful fashion,whilst on a world scale do not seem to be useful in providing differences which are statistically significant. It is concluded therefore that the intriguing joint variation is a false one in the sense that it provides an exact but artificial measure of difference and that on the evidence so far presented, this is not a useful anthropological trait.

(ii)

A Note on the Ability to Smell Potassium Cyanide

Mourant (1950) first suggested that differential ability to smell potassium cyanide solution might be inherited. Kirk et alia (1953) after investigating this in Australia thought that the trait was unifactorial and controlled by a sex linked recessive gene. This has been challenged by Brown and Robinette (1967) who claim that a serial dilution method reveals a trimodal population distribution. They diluted the crystalline potassium cyanide : 10 grams into 100ml distilled water and then by a factor of four for eleven steps. They then recorded the threshold levels of 2885 schoolchildren. No clear pattern of inheritance emerged but unlike Kirk they found no sex differences. In the light of these studies it was decided to test the student control group and the island population with five dilutions of this chemical. The solutions are made up according to the values in Figure (114).

Figure (114)

Potassium Cyanide Dilution Scheme

Solution	Grams/100ml KCN
0	5.0
1	1.0
2	0.1
3	0.01
4	0.001
5	0.0001

Solutions one and two are equivalent to the two modes and solution five approximately corresponds to the third mode of the trimodality of Brown and Robinette. Whilst solution zero corresponds to the dilution used by Kirk in his studies. Figure (115) shows the results for the students and the islanders.

Figure (115)

Holy Island : KCN Thresholds

	Nil	0	1	2	3	4	5	Total
Durham Students	8	42	58	12	20	5	1	146
% (rounded off)	5	29	40	8	14	3	1	
Holy Island Total	8	52	46	16	2	0	0	124
% (rounded off)	6	42	37	13	2	0	0	

There is a bimodality in the student series which is different from what one would expect reading the Brown and Robinette study. A 4 x 2 chi-squared test comparing the students with the islanders at nil,zero,one and two plus thresholds gives a result of 9.47 which is significant at 1-2½% at three degrees of freedom.

There is no marked sex variation in the Holy Island sample, as shown in Figure (116).

Figure (116)

Holy Island : Sex and KCN Smelling

	Nil	0	1	2	3	Total
Total Females	3	26	22	10	2	63
Total Males	5	26	24	6	0	61

The age trends in the sample may help the island group to differ from the student series. The subdivision by age is shown in Figure (117).

Figure (117)

Holy Island : Age Trends and KCN Smelling

	Nil	0	1	2	3	Total
born in 1904 and before	5	19	10	8	0	42
born 1905 to 1924	2	18	17	4	2	43
born 1925 and after	1	14	19	4	0	38

A chi-squared test between the oldest and youngest of the above groups comparing zero versus one versus the rest is not significant. The essential trend,however,seems to be a decrease in smell sensitivity with age,as might be expected. This distortion coupled with the small sample sizes and the only comparative group being entirely unmatched,makes interpretation of this phenomenon difficult at this stage.

Whatever genetic basis this trait has,it has not yet been satisfactorily elucidated. Further and larger studies would seem to be in order to try and solve this problem.

(iii)

The Ability to Roll the Tongue

This is the ability, first described in 1940 by Sturtevant, to curl the tongue into a tube by moving the lateral aspects of the tongue upwards and medially. Many other tongue movements have been described (Cook 1948, Whitney 1949, Hoch 1949, Whitney 1950, Gahres 1952, Bat-Miriam 1962) but this character is the only one examined in this present study.

Results

The large student control from the North of England was used as well as values from South London (Sillitoe 1971) and other data available from the laboratory. The results are given for the students in Figure (118) and for the island sample subdivided by age in Figure (119).

Figure (118)

Student Results for Tongue Rolling

	Male	%	Female	%	Total	%
Can roll tongue	99	64.7	59	64.1	158	64.5
Cannot roll	54	35.3	33	35.9	87	35.5
Total	153		92		245	

The chi-squared test value is nearly zero and so the sex difference is not significant, in Figure (118).

In Figure (119), the 'young' islanders are those born in 1921 or after whilst the 'old' are those born in 1920 or before. The chi-squared tests between the young males and females and the old males and females are not significant.

Figure (119)

Holy Island : Age Variation in Tongue Rolling

	Young Males	Old Males	Young Females	Old Females
Can roll tongue	15	16	12	22
Cannot roll tongue	5	23	5	25
Total	20	39	17	47

Pooling the sexes in the two categories gives the combinations in Figure (120).

Figure (120)

Holy Island : Ages for Tongue Rolling

	Young	%	Old	%	Total	%
Can roll tongue	27	73.0	38	44.2	65	52.8
Cannot roll tongue	10	27.0	48	55.8	58	47.2
Total	37		86		123	

The chi-squared test results comparing the 'old' and 'young' samples in Figure (120) is 8.5 which is significant at a probability level of 1% and not at a ½% for one degree of freedom. Subdividing the 'old' group into those born before and after 1905, the results are apparently very similar with a chi-squared test confirming homogeneity. The combined results, ignoring age differences, are shown in Figure (121).

Figure (121)

Holy Island : Tongue Rolling in Three Samples

	Total No.	Number who can roll tongues	% Tongue Rollers
Holy Island	123	65	52.9
Durham Students	245	158	64.5
South London Parents	126	92	73.0

A 3 x 2 chi-squared test on the results in Figure (121) gives a value of 11.1 which at two degrees of freedom is significant at a probability level of less than .5%.

Discussion

The significantly low values of the Holy Island results compared with the student control group and the South London sample is,in part,due to the contribution of the older individuals in the total island population.

Figure (122) gives the available results from the world.

Figure (122)

Tongue Rolling : The Results of Other Series

Author	Population	Age	Sample No.	Can Roll Tongue No.	%
Gahres	U.S.A.(East Coast)	Students	865	637	73.6
Urbanowsky	U.S.A.(Chicago)	Students	1009	694	68.8
Liu	Chinese	Students	1043	649	62.2
Sturtevant	U.S.A.(California)	Parents	282	183	64.9
Vogel(extract)	Germany	Parents	350	195	55.7
Bat-Miriam	Ethiopian Tribes	Mixed	688	357	51.9
Bat-Miriam	Israeli Jews	?	?	?	53.3
Saldanha	Brazilian Dutch	?	?	?	66.0

All the peoples in Figure (122) are age group selected to some extent with the exception of the Ethiopian tribes which display high intergroup differences. This is the only group which is likely to contain large numbers of older people. It seems likely that the ability to perform a wide variety of tongue movements decreases with age. Vocalising infants can often move their tongues in a complex pattern of positions but young adults can only on rare occasions do this (Cook and others). Whatever genetic basis is responsible for this character,it is much modified by enviromental trends. The people who can curl their tongues only after practice probably represent the group who,when younger could in fact roll their tongues without any difficulty. Sturtevant quotes five such people out of a sample of 127 offspring (3.93%),whilst the discrepancy in the Holy Island sample between the young and old groups is of the order of a 30% loss of tongue rollers. This discrepancy could hardly be made up by the observed variability of Sturtevant. The 'offspring' group of Sturtevant is probably under 50 years of age and so the results cannot be properly compared to the island groups. A good deal more work is required on an age basis before these results can be accepted. The recent paper by Hirschorn (1970) suggests that a wide variety of tongue movements can be aquired over a short period of time.

Tongue rolling,therefore,has a limited value in anthropological studies and will remain of secondary importance until more is known about its genetic basis.

(iv)

The Variation in Finger Length

When the hand is observed in the anatomical position from the palmar aspect,either the second or the fourth finger is the longest. It is the significance of this differential finger length that is considered here. This is a non-metrical observation and so the third possibility that they are apparently of equal length must also be considered. Little has been published of the inheritance of this trait and the possibility that it is purely a function of growth always remains. Similarly many enviromental phenomena can alter this attribute including osteoarthritis and Duypuertren's contracture.

For clarity and convenience it is proposed to use the following conventions in this section:

1 = fourth finger longer than second,

2 = fourth finger equal in length to second,

3 = fourth finger shorter than second.

The hand combinations right and left (R L) are written thus:

11 = both hands fourth finger longer than second,

21 = R hand fourth and second fingers equal,L hand fourth finger longer than second, and so on.

When referring to the finger combinations of one hand the following was used: R1,L3 and so on.

In addition to all this the pooled hand combinations are given letters from A to F (see Figure (124)).

Results

Figure (123) gives the general results for the Durham student series. The chi-squared results show that it is possible to pool the mixed R and L combinations as is shown in Figure (124). There is a significant sex difference when using categories A,D and F. Figure (125) shows the similar results for Holy Island, the absence of the category 2 makes the tables much simpler.

The chi-squared test results are as follows for the Holy Island series : R1 versus L1 (both sexes) is not significant and R3 versus L3 (both sexes) is not significant. As both are homogeneous then the pooled group D can be formed. This further set shows no marked sex difference : the chi-squared value is not significant. Although it is therefore possible to combine the sexes in the Holy Island sample this will not be done to enable proper comparisons with the control.

Comparing males for categories A and F, Holy Island versus Durham Students the resulting chi-squared value is not significant. While females using the groupings A,D and F gave the result 12.56 which is significant between the probabilities of .5% and .1%. Hence some regional differences apparently exist for females.

Figure (126) gives the Holy Island result by age group. The chi-squared test on categories A versus D plus F, gives the result of 16.49 indicating a significant distribution in the different age groupings at a probability of less than 1%. The effect of this age trend seems to be to produce a significantly greater proportion of A types as age increases with a converse and marked diminution in the F category.

Figure (123)

Finger Length : Student Control

Combinations	Male	Female
R1	102	50
R2	14	2
R3	33	43
L1	99	46
L2	8	3
L3	42	46

The following chi-squared tests were performed;

Male versus female;

R1 versus R3 = 11.78 S. at less than .1%

L1 versus L3 = 9.76 S. at less than .5%

R1 versus L1 = NS

R3 versus L3 = NS

So in the latter two cases pooling may be undertaken.

Figure (124)

Finger Length Combinations : the Student Control

Category	Combinations	Males	%	Females	%	Both sexes	%
A	11	89	59.7	38	40.0	127	52.1
B	21/12	5	3.4	2	2.1	7	2.9
C	22	4	2.7	0		4	1.6
D	31/13	18	12.1	18	18.9	36	14.7
E	32/23	9	6.0	3	3.2	12	4.9
F	33	24	16.1	34	35.8	58	23.8
Totals		149		95		244	

A chi-squared test excluding categories B,C and E, males versus females gives a result of 15.10 for 2 degrees of freedom which is significant at a level of less than 0.1%.

Figure (125)

Finger Length Combinations for Holy Island

Category 2 has been eliminated by careful attention to the tests.

Category		Males	%	Females	%
11		48	81.3	41	64.0
31		1	1.7	11	17.2
13		3	5.1	4	6.3
33		7	11.9	8	12.5
Total		59		64	
R1		51	86.4	45	70.3
R3		8	13.6	19	29.7
L1		49	83.1	52	81.3
L3		10	16.9	12	18.7
Pooled Categories					
A	11	48	81.3	41	64.1
D	13/31	4	6.8	15	23.4
F	33	7	11.9	8	12.5

Figure (126)

Holy Island : Finger Length Combinations : Age Effects

Category	born 1904 & before	%	born 1905 to 1924	%	born 1925 & after	%
A	37	42.0	32	36.4	19	21.6
D	4	22.2	6	33.3	8	44.5
F	1	5.9	6	35.3	10	58.8

Distributional Studies

The world literature universally ignores differences through age,sex and laterality. For this reason no other results are given. No trend in the variation of the fingers will be found until proper investigations are attempted and the genetic basis of this trait studied.

Discussion

Due to the lack of appropriate comparative data,the full significance of variation in finger length is not known. It is quite possible that this trait is an entirely fortuitous one occasioned by growth and maturation. It also seems that the trait changes with age and various bony and muscular disorders of the hand. The results presented in this section are given as evidence of the variability of populations rather than as a measure of significant population differences.

Collation

Part (m) is a long section which deals with the final group of non-medical variables. These are the following traits,all of doubtful,unknown or disputed inheritance : finger length,tongue rolling,potassium cyanide smelling,joint sense and handedness. The results all appear to show that Holy Island has a unique population. However studies on the inheritance of these traits and also on the way the traits vary by sex and age leads one to place very little reliance on the results. It is necessary not only to evince some variability from between two populations but also to provide a reasonable explanation as to why it should or should not be there. For these reasons this part has proved to be rather unsatisfactory. At least in the analysis of the results this part is similar to part (l) and similar to both parts (k) and (l) in the uniquness the results demonstrate.

Part (n)

The Place of the Holy Island Study in Relation to Human Biology in Britain

Introduction

The presentation of the available data on the 'normal' variation encountered on Holy Island is now concluded. This part of the thesis attempts to put the study into perspective and briefly considers what the significance of the results might be. Again the use of surnames and the analysis of interrelationships are both commented on in relation to the Holy Island population.

Forms of Regional Studies

Physical anthropological studies on a regional basis are of three broad types. Each approach has some unsatisfactory feature for the student who wishes to select and compare populations studied in these different ways.

Firstly there is the method which involves some preselection of individuals. The criteria used may vary but usually it has some geographical basis. This is the method used by Fraser Roberts (1942b), Brown (1965) and Sunderland (1970) amongst others. These authors select a geographically less transient population by taking into account parental or grandparental birthplaces. If the sample used is extracted from a study which tested all who might be available; then this method limits the sample size greatly. Ideally one would like to select several hundred,on this basis,from the original population but this could mean testing over a thousand individuals in this country,something which may well be impracticable. The alternative method is to identify the population (say) by the origin of its grandparents and then only test those who qualify. Unfortunately here the preselection obscures the gene frequency in the living population as well as giving a gene frequency picture,at best,of a 'grandparental' population. For any simple gene system a grandchild will only have two of the eight genes from its grandparents. The probability that any individual grandchild has the genotype of a grandparent is low and depends on the alleles. This,in addition to the original sampling that has gone into the total population at that time,makes it unlikely that the extracted results reflect very much of a less changeable group of two generations back. The assumption that populations were more stable fifty or more years ago can also be criticized.

The above argument assumes that the gene pools remain stable over several generations and implies that there is genetic homogeneity amongst the grandparental gene pool. But random mating and the lack of selective pressures depend upon the type of population studied and the genetic systems examined. In fact for most small genetic studies the Hardy-Weinberg effect is not likely to be in operation. If the effect does not operate at the level encountered in most population genetic studies then one would expect some randomness of genetic change over the generations. Some evidence that this is possible has been presented for Holy Island (Cartwright 1973). If random fluctuations occur in other populations then any sampling technique will obscure even further the complexity of the results,and especially a double sampling method. That is,one would expect wide fluctuations in gene frequency yet,not know from the results which component was being observed; that due to a drifting situation or that due to a sampling effect.

The second type of study is another sampling technique but on a much broader basis. This method involves little or no pre-selection of subjects and all who are tested are assigned to some meaningful category in the results. This method has been used, for example, by Kopeć (1970) by using a person's postal address. The main difficulty with such samples is that there may be bias of the people who take part; not all the population are blood donors, nor do all recruits join the air-force. It could be argued on these lines that all samples ever taken are biased in some way. However, if the sample is large enough then the bias may be ignored. But all samples are capable of being broken down into smaller units, it is often desirable to do so, yet we never know the threshold beyond which a sample no longer reflects the gene distribution of a population and merely reflects the bias of its representatives. The interpretation of the results of such studies always presents a dilemma; in part through the question of sample size already mentioned, and in part through the lack of accompanying demographic information. The geneticists would like to know the state of population movement, the distribution of the breeding sizes of the population, or its sub-populations and other facts which would help them to decide if the results were a product of drifting forces or historical population movements or natural selection. This type of information has to date, been almost universally absent. The role of natural selection in polymorphic situations is again in a state of flux following the discovery of the many protein based polymorphisms (Harris 1971). Also the studies on kinship and mating patterns in Western Europe, at least those studies which have any genetic relevance, are pitifully few.

The third type of study is the mostly small scale examination of distinct and often isolated populations. This type will be considered in more detail later. The studies arose in part to investigate genetic processes, in part to eliminate sampling bias and in part to consider situations where the demographic information lacking in previous studies could, relatively, be easily obtained and manipulated. However the methods of small population investigation pose new problems. The smaller the group, apparently the more randomisations take over to obscure the effects of selection or hybridisation (Cartwright 1973). This randomisation is a product of social, historical and geographical factors and is by no means due to a single cause (Boyce et alia 1967, Cavalli-Sforza 1956 and 1959, Harrison 1970 and Harrison et alia 1971).

Each of these broad modes of study have demonstrated genetic variation between populations. It is also an unfortunate fact that some intergroup differences have either been obscured or overemphasised by inappropriate comparisons between populations tested by these different approaches. The author realises he is himself guilty of this in his present work by comparing the mainland Northumberland samples with the island population. It is difficult to see how this may be avoided in the future, especially as the processes of selection of many of the earlier studies have not been recorded. Here is a further reason why genetic differences occur between groups.

The Significance of Regional Heterogeneity

When considering the above passage, it is clear that regional variability might often be found. What is obscure is why these variations should be there. Are we demonstrating randomness due to our own techniques or are they the product of that group of randomising phenomena named genetic drift? Even very large samples could be regarded as an unrealistic breeding population to study and subdivided into smaller 'breeding units'. Possibly the results are not randomisations at all but due to genuine heterogeneity. There is a tendency always to look at this aspect of the problem first and ignore the possibility of poor design of the study. The interpretation of genetic heterogeneity often follows a fixed pattern of firstly an attempted geographical explanation followed by an enviromental one or an inappropriate historical one. In this country,for example, one expects the North and West to have higher blood group O frequencies than the South and East. This is then followed by historico-geographic and climatic type interpretations which take little account of known population genetic theory. This type of interpretation has become less attractive since the finding of large intervillage differences, say,in South America (Gershowitz et alia et sequentia 1970). It is true one is trying again to compare two possibly similar genetic structures. The fact remains that it is the heterogeneity that is taken to be meaningful rather than the homogeneity. A simple genetic interpretation of basic evolutionary theory would suggest,however, that heterogeneity is desirable whilst homogeneity would be fatal. In the tiny population system on Holy Island all factors tend to lead to some type of genetic variation and this has been in part demonstrated. In general terms it seems that we would be more successful in trying to interpret why genetic similarities occur than we have been in attempting the opposite. Perhaps we should regard heterogeneity as an expected phenomenon and homogeneity in need of further explanation and interpretation.

This might be especially the case in Western Europe,an area lacking gross variation in its enviroment. The mechanisms whereby industrialised groups maintain their genetic identity in different geographical locations have been little investigated. An exception here is the study by Hatt and Parsons (1965) of British immigrants to Australia. Similarly there have been few studies that examine the progress of unifactorial genetic traits towards 'hybridised' homogeneity; haemoglobinopathies studied in the New World are exceptional in this respect along with some other studies on American Negroes.

Another factor which is at once the basis of heterogeneity and a criticism of the types of studies carried out is that the true breeding population is poorly defined. Little progress has yet been made in this country as to the geographical and numerical distributions of the effective populations. The estimates made in this thesis are mainly historical and like all such estimates make several unwarranted assumptions. The subject is dealt with theoretically by Sewall Wright (1969) but not satisfactorily from a practical viewpoint by any single author. From the New Guinea studies by Malcolm et alia (1971) it seems that geographical and linguistic barriers do not stop gene flow to any great extent and so isolates in whom the breeding population was thought to equal or be directly proportional to the total population should be re-appraised.

Studies on Isolates

The term 'isolate' can be taken to mean any small and separate group which might be genetically distinct but which is socially and/or geographically unique. In this way one can include European religious groups,inhabitants of islands and small primitive communities.

The absolute numbers can range from several thousands to under a hundred. However this term may be used, there are always many exceptions and amendments that may be applied. As defined here isolates may be composed of many differing types of peoples; urbanised or rural, primitive or industrialised. Implicit also in the definition is that they can all be studied by similar means; that is by the third method mentioned above. In addition one isolate is rarely contrasted with another and usually it is not possible to do so.

The basic evolutionary genetic unit was one of a hunter gatherer community, at the most a few hundred strong. This was the group size which led to the evolution of <u>Homo sapiens</u> and existed universally until early urbanisation started to occur some 8-10,000 years ago. In this respect isolates have great evolutionary significance. If such small groups were capable of evolutionary changes, then are there any such groups now that are also capable of such changes? Subsequent to 10,000 years ago a population increase may have initiated and driven a 'wave of advance' across Europe coincident with the spread of farming and an end to the early phase of isolation (Ammerman and Cavalli-Sforza 1971). Isolate studies on primitive farming and hunter-gatherer groups today are to some extent examining this phenomenon although few such studies have included much demographic information until the last few years. The studies have not compared one type of subsistence economy with another, genetically or demographically.

An early study of this type was by Birdsell (1950) in Australia and this has been followed by others : some in the Pacific area (Friedlander et alia 1971), some in South America (Gershowitz et alia et sequentia 1970), some in North America (Niswander et alia et sequentia 1970) and Greenland (Persson and Swan 1971). The modes of analysis have become more sophisticated over the years and now often demonstrate inter- and intra-group variations. At first such differences were associated with a few social facts about the people who were being studied,for example Giles et alia (1966),but more recent studies using the coefficients of kinship and patterns of intermarriage are starting to bridge this gap (Malcolm et alia 1971 and Salzano and Freire-Maia 1970).

Isolates in other segments of the population could be said to have taken over from the hunter-gatherer in the sequence of ongoing evolution. Larger communities are more likely to exhibit changes through natural selection. The main value in the analysis of religious isolates is in the study of extreme degrees of consanguinity with the consequent medical problems (McKusick 1964) and in the use of complete records to observe the workings of situations studied by the theoretical geneticists,for example amongst the Hutterites (Kurczynski 1969). Also the operations of genetic drift (for example Glass 1952),hybridisation and migration may be observed from such papers.

Geographically isolate groups tend to be more complex in structure than other types for practical reasons; they have not achieved the specific identity of tribal and religious populations nor have they rigid limitations on their mating patterns. The demographic records tend to be poor in many European 'isolates' and the inhabitants are often opportunistic and great travellers. Nevertheless as they provide situations with,at first sight,specific and limited breeding populations they are favoured sources of material. Many islands fall within this category such as the Susaks (Dolinar 1960),the Åland islands (Eriksson and Forsius 1964) and Tristan da Cunha (Roberts 1970).

All show characters which are normally regarded as being different from generalised population samples. Often the island samples are compared with control groups which are inappropriate in that they represent different modes of collection and analysis (this study). The island samples are often nearly complete populations with many interrelationships whilst the controls used are often the nearest available population samples collected at random.

Isolates in general present a wide spectrum of type of group 'isolation'. Some are as nearly perfectly isolated as possible, whilst the other end of the spectrum is exemplified by disintegrating religious groups in the United States. How then do normal or generalised groups or populations harmonise with these calibrations of isolates and their isolation? Population density, the proximity of urban centres and the availability of transport must all play a part but it seems plausible that there is an overlap between the least isolated 'isolate' and the most isolated group from the general population. The term 'isolate' as defined earlier tends to lose its specific meaning at the least isolated end of the scale and merges into the part of the population that may be defined as 'normal' in geographical, social and demographic terms. The group living on Holy Island tends to fall into this transitional category between the two types.

It seems a natural step to turn to the study of the apparently normal genetic situation rather than the manifestly abnormal. The studies in this country on the demographic background to the genetics of rural populations have shown that in the South Midlands marriage distances can be limited by social class (Harrison et alia 1971) and ten foot wide streams (Boyce 1967) but the present study shows that the situation may be more complex in the North than in the

Midlands. It is possible that the demographic and thus the genetic situation varies between coastal and inland as well as between urban and rural. Evidence has yet to be produced to substantiate this but sociological studies (Williams 1963) suggest that continuity in a community can occur only by accepting into the group new members who hold the same attitudes as well as the same type of occupation as the rest of the group. Thus fishermen produce and perpetuate one type of community whilst farm labourers produce another; it may be possible to distinguish such communities demographically and even genetically just as Galt (1968) has distinguished various types of Scottish border communities in a socio-demographic fashion.

The Comparability of British Population Studies

The different types of genetic study have been discussed at some length earlier, in addition there are various possible demographic approaches which may give different apparent results. The value of very large series such as Kopeć (1970) is that parts may be compared with the assurance that the results at least all have similar origins and treatment. The possible variations in sampling mentioned earlier, the possible differences of technique and variations in the response of participators, could all account for untestable differences in the results. It is reassuring in this respect that Fraser Roberts (1953) and Kopeć (1970) obtain similar results for rural North Northumberland despite almost a generation difference in time.

The basic problem of whole population studies, isolates or otherwise, is one of comparability. How may a related and unique group of people be compared with a sample from a neighbouring, larger and less isolated area? High degrees of consanguinity are not likely to be a great problem in British series,but many interrelationships are to be found in rural situations. If the probability of having genes from a common ancestor could be computed then it might be possible to demonstrate to what extent the genetic results are influenced by the relationships and eventually it might be possible to compare one small group with another. Another potential method for comparing small interrelated groups in a genetic,historic and demographic fashion is by the use of surname analysis. This is briefly discussed in chapter one and in part (k).

The Use of British Surnames in Population Studies

English surnames became fixed in the fourteenth century and were commonly used after that time. Reaney (1967) considers that the origin of surnames to be as single names,patronymics,occupational names and nicknames. There is little regionality here for the Human Biologist,other than some local terms of occupation or local and specific nicknames or local place names. Many local place names tend to be very common throughout the country; Bolton,Burton and so on. A complicating factor is the adoption of English surnames by many generations of immigrants. Also the changing of surnames and the adoption of various aliases and the assumption of maternal names by some illegitimate children should all be taken into account when the subject is being studied.

Since Victorian times surnames have been considered to be indicative of specific origins,despite the above facts,and to give some clues to the locations of settled groups in Britain. Guppy (1890) formulated this into a detailed analysis of English and Welsh surnames and recorded their distributions and variations.Others have studied the surnames of Scottish (Black 1937),Irish (McLysaught 1957) and Manx (Kneen 1937) origins. Nowadays it is realised that surnames have a quasi-genetic basis being linked with the Y-chromosome. Several attempts have been made to link surnames with genetic attributes and Beddoe (1885) was one of the first to discuss this potentially valuable aspect. Other anthropological studies have occasionally made use of surnames in choosing groups to study anthropometrically (Davies and Fleure 1936 and Fleure and Davies 1958) and serologically (Schaede 1929). Genetic differences in relation to surnames was not studied in this country until 1939 when Fisher and Vaughan noted that recent population movements could lead to associations between the ABO blood groups and certain surnames. Fraser Roberts (1942a and 1942b) using surnames noted an ABO difference between North and South Welsh names amongst the populations living in North Wales. He used Guppy's surname distribution as a means of regionalising the Welsh. This technique has been extended amongst the Welsh by Watkin (1965a, 1965b and 1966) for the ABO blood groups and by Legon (1963) in the study of gastric carcinoma amongst the North Welsh. Ashley and Davies (1966) concluded that surname analysis was a valid method of group subdivision for the Welsh,but that the population structure was changing so rapidly (by migration) that this would not be a meaningful method within a few generations. Since that time several papers have appeared using surnames as a basis of analysis (Ashley 1967a,1967b, 1967c and 1969).

Hart (1944) has studied serological attributes and Irish surnames in a similar manner to Watkin. Hatt and Parsons (1965) have used surnames to study the differential effects of British immigrant groups in Australia. These authors make basic use of the works quoted earlier.

Kopeć (1970) uses such studies to subdivide some Glaswegian and Liverpudlian populations.

A study of the Aran islanders by Hackett and Folan (1958) makes use of surnames in a different manner. This work compares the historical structure of the island with the present day genetical results.

Dobson and Roberts (1971) use English surnames as indicators of gene flow through historical time whilst this present study notes surname variations in Holy Island from one generation to the next.

Another branch of surname use includes the analysis of marriage frequency between persons of like name. From this an index of inbreeding may be computed (Crow and Mange 1965). Shaw (1960) uses a similar concept in the analysis of Spanish surnames which reflect both parental origins. The method of Crow and Mange has also been used by Hussels (1970). The analysis assumes that offspring are produced by all isonymic marriages and that the marriage registers reflect the true demographic state of the community. Surnames taken together serve to characterise a specific group of people. The names of the Tristan islanders are not unique but few in number, whilst the Boer settlers have passed their surnames (about forty) to nearly one million living descendants (Dean 1971). The Amish have also a high frequency of a few surnames (McKusick 1964) and this is true of other isolated religious groups (see, for example, Glass 1952).

Characterisation of groups by surname frequency bears certain resemblances to the study of genetic polymorphisms, in that the results could produce patterns in the population which are a product of historical, demographic and social trends. Such an analysis could be applied to the British Isles. Not only do the Welsh have a unique set and distribution of surnames but the appropriate selection and regional comparison of the names can demonstrate local boundaries of language and historical units (Fraser Roberts 1942a). However it is erroneous to suppose that the distribution of surnames is constant in small populations throughout historical time. The average rate of turnover of males with a particular surname on Holy Island is 64 years or approximately three generations. Moreover each surname is moving at a different rate and so this also must be taken into account. It is likely that most small English communities will resemble Holy Island in this respect and this has some substantiation by Dobson and Roberts (1971) and Buckatzch (1951). It is also possible that non-metrical scaling techniques could be applied to surname data to determine the interrelationships of parish populations (see Kruskal (1964) and Kendall (1972)). The factors which influence the appearance, changes and disappearance of surnames are the same as for any simple genetic variable : migration,chance,differential fertility and so on. Because of this,studies on surnames should define these influences in order to interpret the results.

Another major use of surnames in British communities has been with regional names. Care is needed here,however,in the analysis of typical Welsh or Scottish names. The analogy with genetic polymorphisms holds a useful line of interpretation here. There is a tendency to assume that a regional name confers absolute regionality. It is quite possible that the remote ancestor who confered the name on a descendant has been swamped genetically with many generations of non-regional ancestors. And so nationality by surname is only valid after research into the pedigree of the individuals concerned. This is very tedious for population studies but there are various examples in the literature that fall into the trap of assuming nationality from surnames alone.

It is possible to compromise to some extent here and take as an index the origin of the names of the parents and grandparents and their places of birth. This has been done in relation to the Manx population (Mitchell 1971).

It is also possible to make use of unique or 'private' surnames, especially English ones. These are names which occur in very few families for a wide variety of reasons; they could be names recording a unique locality or some unique,historical palaeographic error. These names could be said to be akin to genetic mutations. Guppy (1890) is useful as a rough guide to determine if a name is unique or not. 'Private family surnames' may be defined as those originating from a specifically identified couple and all the people with the name can trace descent from this couple. Some documentary proof is thus required. These names are of especial use in tracing genetic movement and fertility. Examples of this can be seen from Holy Island - the names Markwell and Cromarty are virtually unique in these forms of spelling. Both originate from couples who lived on Holy Island in the 1720's and now both names have spread throughout the world.

The majority of modern genetic studies use Guppy (1890) as a guide (Fraser Roberts 1942b and Ashley and Davies 1966). This is unfortunate,if Guppy is the sole source work,because of the mobility of names. It would be appropriate to test if the results of Guppy will be the same as the results of today. The modern distribution of surnames in Britain is not known,but this must certainly be defined before any modern study has relevance (Leeson 1965). Because of

Reaney's views on the origin of surnames it is unlikely that the investigation of surnames will produce a clear set of results, but it is one which seems well worth the effort of study.

This section has dealt with the use of British surnames in general terms and in relation to this thesis. It is commended as a subject that brings together the three otherwise loosely connected disciplines of history, demography and genetics. If studies are undertaken it is worth bearing in mind the bases of the several component disciplines so that the results may be properly interpreted.

Collation

Part (n) has dealt with some aspects of analysis of the genetic and allied data from the living population on Holy Island. Firstly the nature of the study is itself considered in relation to the various methods of data collection which might be used and also the techniques used in the comparative work. The conclusion is that comparative data must be examined with care before weight is placed on the apparent similarities or differences they introduce. It may be that such considerations at this stage preclude any further and more sophisticated statistical analysis (say, a study of biological distance), before a more detailed analysis of the demographic attributes of the population is undertaken. A more general critique of the concept of genetic heterogeneity follows. It is argued here that heterogeneity is easier to explain than homogeneity. This is because small groups have greater evolutionary significance than large populations. It is also implied that apparently large populations are not homogeneous in respect to breeding groups and are composed of much smaller genetically significant units. There is no direct evidence for this but some work is quoted which suggests the Holy Island analysis is unremarkable in its demographic and genetic heterogeneity; although the actual results do characterise the living island population.

There are suggested two lines of analysis which might be useful further to understand the population dynamics of the island. The first of these is dealt with in some detail in the form of an essay on surname studies and their utilization in British populations. Careful use may be made of surnames on Holy Island as historical, demographic and genetic markers. Viewed as a gene on the Y-chromosome, surnames may be employed as a means of effecting population comparisons between any complex groups. Similar comparisons cannot be made with purely demographic or genetic criteria and in this respect surnames provide a potentially useful tool for this type of analysis.

The second suggested line of analysis is dealt with elsewhere in the thesis and consists of the study of interrelationships. It is quite possible in this type of population study that numerous blood relatives exert some influence on the genetic and allied results. This is implied in the first chapter. Further details will be found in parts (k) and (t). An attempt to study the potential effect of relationships has been initiated,to date in a very simple fashion. This may prove to be a fruitful line of analysis.

In all,this part introduces some factors which are important in understanding the results found in this chapter.

Part (o)

Summary of Chapter Two

This chapter consists of six parts and reports on the non-medical variability collected from the living island population. The first two sections deal briefly with the methods used and details of the modes of collection of data. Part (k) deals with the results considered to be unifactorially inherited. The Holy Island results are contrasted with material from several sources; two series from Northumberland,several from the North of England,some from the South of England,Scotland and abroad. The use or misuse of such varied data is mentioned in several places throughout this chapter and especially in part (n). The phenotypic analysis of the results shows that the island is unique in its distribution of many traits. One figure shows the entire set of results as a series of 2 x 2 chi-squared test values and significant results are found scattered throughout. Despite the many unusual phenotype frequencies,the Hardy-Weinberg proportions are only in disequilibrium in two systems : MN and Duffy. This is commented on in part (k) where attention is drawn to the results one might expect from the demographic analysis in chapter one. Individual comments are made about the unifactorial system as well as a general series of comments at the end of this part where the topic of the effect of relationships is reintroduced.

Part (l) briefly demonstrates an analysis of dermatoglyphic and skin colour results. Much is made in this part and in part (m) about the inadequacies of the data. This is due to poor collection of data,small sample sizes,large degrees of variance or the lack of suitable material for comparison. In general these factors obscure proper interpretations of the results,although it appears that the islanders are lighter in skin colour than a sample of Durham students, have different finger pattern types compared with a South Midlands series and have palmar ridge and pattern differences. The interpretation of palmar pattern types is another variable to be added to the above list of sources of error. The significance of the observed variability in part (l) is therefore in some doubt.

Part (m) considers variables which may be inherited. All show variability when compared with other data. As in part (l) the interpretation of the results is obscure; partly due to the series of difficulties mentioned above and partly due to the additional disadvantage that the reasons for the existance of the variables is less well understood than those traits in parts (k) and (l). The variability,for example,shown by hand clasping could be an entirely random phenomenon and the recorded results due to sample collection and so on. For such reasons part (m) contains some rather disappointing traits.

Part (n) discusses several problems relating to population studies in general; the modes of analysis,isolate studies and surname analysis are three of the main sections. The aim is to relate this chapter to aspects of chapter one and biological anthropology in toto.

This chapter presents the genetic data and presents non-genetic variability data in order to consider their use in understanding the living Holy Island population.

CHAPTER THREE

Medical Variability

in Holy Island

Part (p)

Introduction and Methods

Introduction

The aim of this aspect of the work was to initiate a series of screening tests, the results of which would be helpful to the islander's general practitioner as well as giving an indication of variation in a small ageing population. Not all the results are presented here. With the permission of each islander, the medical information on their doctors' records was examined, but these data were not used in the thesis.

Methods

Data were obtained from an examination of the blood, urine, electrocardiograms, sphygmomanometry and a note was made of other conditions of medical genetic interest. Both clotted and anti-coagulated blood specimens were obtained, the latter in fluoride and sequestrene tubes. The specimens were delivered within 24 hours to the pathology laboratory at the Queen Elizabeth Hospital at Gateshead. Thin blood films were examined for cell appearance, whilst the blood was analysed for haemoglobin content (Hb), packed cell volume (PCV), white blood cell count (WBC), the erythrocyte sedimentation rate (ESR); and the mean corpuscular haemoglobin concentration was calculated. The serum was examined for levels of cholesterol, uric acid, sugar, urea, sodium, chloride, carbon dioxide and potassium. The results of the last of these are not included as they were abnormal due to red blood cell leakage. The haematology was by the standard methods* whilst cholesterol was a manual determination by Sackett's

* The haemoglobin concentration was estimated by the cyanmethaemoglobin technique.

modification of Bloor's method (see J.BIOL.CHEM.,64 (1925) 203).

The methods determined by the Technicon autoanalyser were as follows :

Urea by diacetyl monoxime method N 1 C,

Sodium by flame photometry method N 21 A,

Chloride by ferric nitrate and mercuric thiocyanate method,

Carbon dioxide by phenolphthalein method,

Uric acid by phosphotungstic acid and sodium carbonate method modification N 13 B,

Glucose by the glucose oxidase method of Marks.

The Cambridge Transrite 4 portable electrocardiographic machine was used to take the recording from the limb leads only. These results have not yet been fully analysed and are not reported here.

Blood pressure was recorded using the ausculation method with a standard manometer. The results were double checked.

The urine was examined with Ames Labstix on collection. This gives the pH,glucose,protein and blood content results.*

Miscellaneous items were noted as they arose. The one reported here concerns premature osteoarthritis of the hip.

*The Labstix are dipped in fresh urine and the coloured results matched with those printed on the bottle.

Part (q)

The Medical Results

Figure (127) gives the results of the medical tests for the Holy Island population. The results for carbon dioxide,chloride and sodium are presented as the results for a nearly complete,small community. The physiological levels are under close control and the results given here are within the normally quoted range. They are not remarkable in any way. The other results are commented on in turn, the serum cholesterol and uric acid results are given in some detail. In addition the urine was examined for abnormal amino-acids by high voltage electrophoresis but no anomaly was detected.

Urine Tests

The pH values seem to indicate a fairly ordinary distribution of results. Many tests showed traces of protein and were ignored. The protein 'one plus' result was encountered in old people and the significance was not determined. The glucose 'medium' result occurred in two known maturity onset diabetics. The result 'some haematuria' was found in an individual with no other detected anomaly.

Blood Pressure

No results by age and sex are provided as it is thought the sample is too small for such a breakdown,although it is an analysis that is normally carried out. The results have an observer bias towards 55,65,75 and so on. However the totalled means are within normal limits and all the results are within two standard deviations of the means except for one diastolic and five systolic values. The highest

Figure (127)

Blood and other Medical Results for the Total Population on Holy Island

Variable	Number	Mean	SD	Normally quoted value *
Haemoglobin	120	94.4	9.3	14.6mg% = 100%
PCV	119	41.5	3.8	
MCHC	119	32.7	0.9	
WBC	119	6424.0	1792.0	
ESR	99	8.7	skew distribution	
Cholesterol	125	181.3	58.1	100-250
Uric Acid	117	5.2	1.4	less than 5
Sugar	125	83.3	27.2 **	
Urea	123	36.5	11.4	
Sodium	109	135.6	5.1	133-152
Chloride	120	103.4	3.9	95-107
CO_2	120	20.4	1.9	24- 34

1) * from Gateshead Hospital
** includes one value of 330

2) The quantities given as means are all in the standard units e.g. the electrolytes are in MEq/litre, the other serum constituents in mg% and the haemoglobin is expressed as a percentage.

3) Abnormal films were found in five instances; three slight hypochromia, and one each slight microcytosis and slight poikilocytosis. All are women without other detectable anomalies.

4) Blood pressure results ; Diastolic mean 78.47 (s.d. 15.83) and systolic mean 129.35 (s.d. 21.60), all in mm of Hg.

5) Urine tests ; pH 5 = 71 (58.2%), 6= 44 (36.1%), 7= 7 (5.7%). Ames Labstix results ('trace' proteins and ketones ignored) 'glucose medium' =2, a man and a woman both over 70 and diabetic. 'Protein +', =3, a man of 70 and two women over 60, no other anomaly. 'Blood +' = 1, a woman of 60 no other anomaly.

6) Only adults were tested.

diastolic value is 125 mm Hg and was accompanied by a systolic value of 200 mm Hg. The other four high systolic values (one at 190 and three at 180 mm Hg) were accompanied by diastolic values within normal limits. The person with both values unusually high was a newly found hypertensive.

Haemoglobin

The value of 100% is arbitrarily given as 14.6 gm/100ml. The normal range in men is quoted as 92.5% to 123.4% with women slightly lower. However two standard deviations from the mean for the Holy Island material,which is somewhat lower than the normal estimates, include all the values with the exception of four individuals,one person who was dehydrated with a value of 118% and three who were anaemic but asymptomatic with haemoglobin percentage values of 74, 72 and 66. If the lower limit of the published range for haemoglobin is to be accepted,however,then 34 of the adult islanders have abnormally low levels. The published normal values also have their limitations as samples and should include subdivisions by age as well as sex.

PCV and MCHC

The PCV values are at the lower end of the normal range and, in conjunction with the low Hb values the MCHC levels are also low. For the MCHC,six individuals are above the second standard deviation, when comparisons are made within the island sample,and only one at the lower end of the range at 31.

White Blood Cell Count

This is a non-specific entity,varying with age,sex and many sub-clinical infections as well as with a wide variety of specific pathologies. The normal adult range is 4,000 to 10,000 whilst the range calculated from the island results corresponds fairly well with this being 2,800 to 10,000. The actual values include seven over 10,000 (four at 11,000; two at 12,000; one at 13,000). No anomaly was found with any of these higher results.

Erythrocyte Sedimentation Rate (Wintrobe)

The results of this test indicate non-specific pathologies associated with abnormal constituents of serum proteins. 'Normal' is usually quoted as less than 9mm/hour in men and less than 20mm/hour in women. The Holy Island results demonstrate the expected skew distribution. Note is only made of two abnormal values,both without other anomalies,one at 41mm/hour and the other at 69mm/hour.

Sugar (Glucose)

None of these results can be regarded as fasting values although they were all taken in the morning. Thus the upper normal limit of about 110 mg% does not apply. However there is only one grossly abnormal result from a known (and at that time uncontrolled) diabetic. This person had a blood glucose value of 330mg%.

Urea

A normal range of this waste product is usually 17 to 24 mg%. However 36 of the islanders have values over 40mg%. Two standard deviations of the range of island results gives an upper limit of 60 mg%. There are four people with values over this from 64 to 75 mg%.

Part (r)

The Utility of Medical Screening Tests

In conjunction with the results from the electrocardiogram, several heart anomalies were found,five mild anaemias,one severe hypertensive,a case of incipient gout and a case of diabetes were all uncovered by this series of tests. This is a very small population study when compared with many medical surveys. However this island population is an ageing one and has been demonstrated to be unique genetically and demographically. The number of unsuspected disorders (5%) was high although most were mild in type and easily correctable.

The main problem posed was the perennial one of 'normality' and the range of 'abnormality'. It is shown several times that the published normal range was inappropriate for this sample. This is not surprising as most 'normal' ranges are determined by using young adults and are not aged based in any way. The most serious criticism of such quoted data are the facts that the sizes,sex,ages,regional origins of the populations tested are not available. It is not common for such series to be from published papers which might reveal this information,rather the authors of texts amass a series from some laboratory records or test a large and readily available population such as,nurses or medical students. This is again emphasised in the case of uric acid levels (vide infra). The other criticism of these ranges is that they do not indicate the range about the mean; either as two or three standard deviations,or if the range is deduced from a normal distribution.

Besides the fairly clearcut anomalies quoted here,the study also produced about a dozen isolated and apparently abnormal results which were not accompanied by other abnormal results from these individuals. This may be a facet of the range of normal distribution and of no significance or it may be due to genuinely anomalous results and the precursors of some illnesses. From this point of view it might be of interest to follow up the population for a protracted period.

In relation to the population in general, the range of normal values all seem to be more scattered along their range than one might expect. This is reflected in the higher standard deviations associated with some of the systems. This is perhaps to be expected in a sample which is as heterogenous as the island population. Also it could be related to the small size of the population.

In relation to the rest of the survey, the tests took up a third of the time with each person and on the whole were appreciated by the participants and by the local practitioner. The value of the results is not reflected in the amount of space given to them in this thesis and much more could be made of the analysis of these data.

Part (s)

Serum Uric Acid

The Holy Island mean for serum uric acid is above the normally accepted maximum level. The results also have a large standard deviation. The total results show a bimodality (see Figure (128)). The sample analysis by age and sex is given in Figure (129). The total male mean is 5.98 whilst the female mean is 4.88. However there are two convergent age trends. The younger males have a mean of 6.22 decreasing to 5.75 in the oldest group, whilst the position is reversed in women with the younger women having a mean of 4.31 and the older women a mean of 5.46.

The men still have a higher proportion of individuals with values of 6.5mg% and over. But this again decreases with age in the sample. The individuals with known gout were well within the normal range.

Some equivalent figures are available from random samples obtained by Hewitt (1961). The samples were obtained from the town of Leigh and from a rural population in Wensleydale. The results are given in Figure (130). Here the urban sample is slightly higher than the rural but no similar age trends are seen in the male sample. The Holy Island population has higher levels of uric acid than the series studied by Hewitt. The three major causes of hyperuricaemia are renal failure, some drugs and leukaemia. All these are unlikely in the islanders and it seems that a possible answer might be associated with the diet. The island has a high fish diet. The extent of fish in the diet of the island has not been investigated but it is likely

Figure (128)

Serum Uric Acid

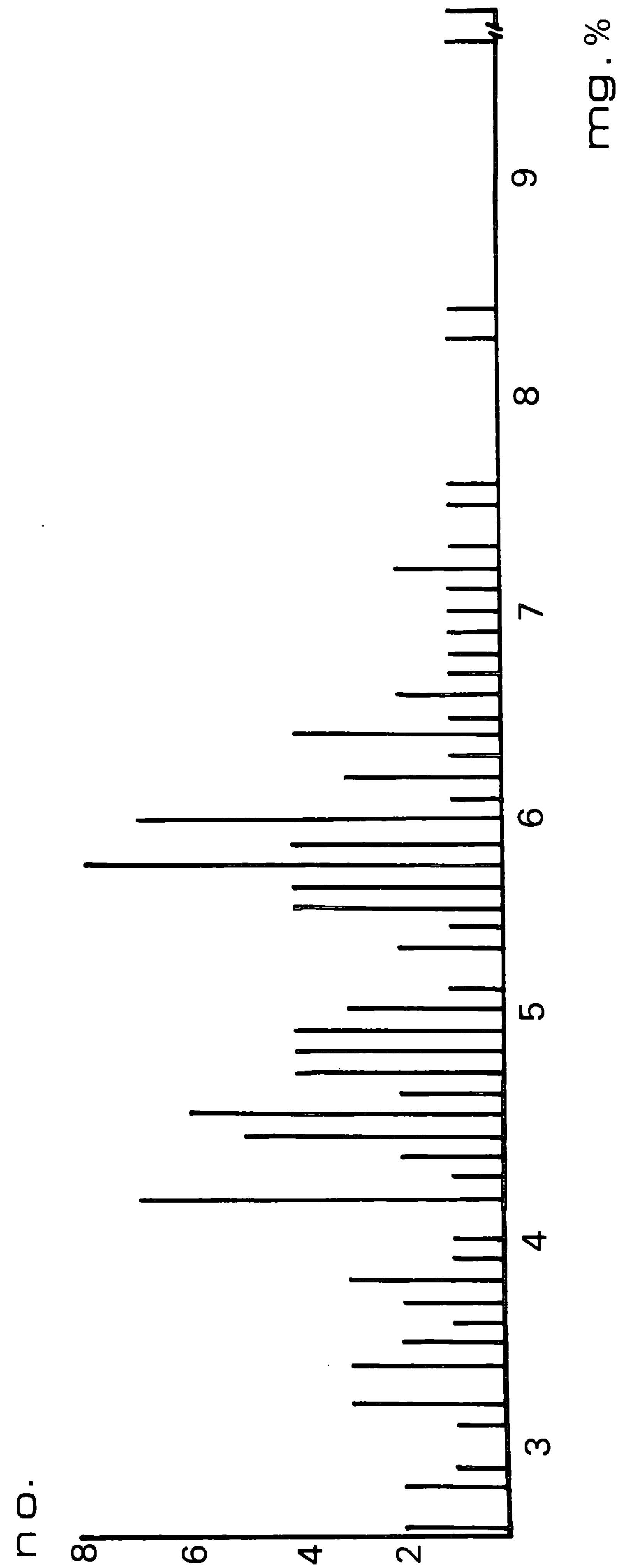


FIGURE (129)

SERUM URIC ACID LEVELS

URIC ACID mg %	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	Total	No.	Mean	%6.5+
MALES																				
born 1925+	2			1	1	1	2	6	2		1	1			1	1	118.25	19	6.22	31.58
born 1905+					3	3	4	2	1	2		1					95.00	16	5.94	25.00
born 1904-	1				3		7	4	1	2							103.50	18	5.75	16.67
Total males	3			1	7	4	13	12	4	4	1	2			1	1	316.75	53	5.98	24.52
FEMALES																				
born 1925+	1	2	4	2	6	1	1										73.25	17	4.31	0
born 1905+		3	2	6	6	4	1	3			1						124.25	26	4.78	3.85
born 1904-	1	2	3	2	2	1	6	2	1	1							114.75	21	5.46	9.52
Total females	2	7	9	10	14	6	8	5	1	1	1						312.25	64	4.88	4.69
MALES + FEMALES	5	7	9	11	21	10	21	17	5	5	2	2			1	1	629.00	117	5.38	13.68

Figure (130)

Serum Uric Acid Values Divided by Age and by Sex

Age	Number	Mean	Range	% over 6.5
Wensleydale Males				
35-44	85	4.26	1.9-6.6	1.2
55-64	54	4.44	2.3-6.8	5.5
75+	25	4.65	3.0-6.4	4.0
Wensleydale Females				
35-44	90	3.54	2.1-5.1	0
55-64	60	3.91	2.1-6.8	3.4
75+	33	4.09	2.4-6.4	3.0
Leigh Males				
55-64	138	4.88	1.7-8.4	8.0
Leigh Females				
55-64	150	4.29	1.1-7.5	3.4

to be higher than that of the inhabitants of Wensleydale or Leigh.

Conflicting results have been found in relation to social class. Saha and Banerjee (1970), for example, find lower values with low social class. Howell (1970) with a larger sample finds no correlation between uric acid levels and class.

Part (t)

Serum Cholesterol

The serum cholesterol results are analysed in greater detail as an example of how such a population variable may be dealt with.

The Results

The results are outlined in Figure (131) along with data taken from Hewitt (1961). The Wensleydale and Leigh results are for three specific age groups which do not fully correspond with the age range found on Holy Island. The age groups were chosen because they agreed most nearly with the island age groups. Females have higher values than males in all but one category (young Wensleydale). The Leigh values are slightly higher than the rural series whilst the Holy Island results are exceptional in their consistantly low results. The totalled means for Wensleydale are 233.0 mg% for males and 253.5 mg% for females while the corresponding figures for the island are 175.4 and 195.6 (both in mg%).

The trend of the Holy Island results is to increase the mean with increasing age. This is not the case with the other two series. Here the older groups have lower values than younger individuals. The values in the old people are still very much higher than the island sample and may be due to a selective process : those with higher serum cholesterol values dying before they reach old age.

The method used by Hewitt was the same as that used on the island specimens. It seems that here is another unique property of the Holy Island population and one which is worth investigating further. Social class may be important here; both Banerjee and Saha

Figure (131)

Serum Cholesterol Values by Age and Sex

Age	Number	Mean	Range	% over 300mg%
Holy Island Males				
Under 45	22	153.2	80-200	0
46-65	18	181.1	80-280	0
Over 66	19	195.8	80-260	0
Total	59	175.4	80-280	0
Holy Island Females				
Under 45	17	171.2	80-280	0
46-65	27	201.1	120-320	3.7
Over 66	22	207.7	80-360	13.6
Total	66	195.6	80-360	6.1
Wensleydale Males				
35-44	90	244.2	148-477	12.2
55-64	141	248.4	156-426	12.0
75+	23	213.2	114-283	0
Wensleydale Females				
35-44	104	241.8	139-371	11.5
55-64	155	280.7	98-511	33.0
75+	26	252.5	157-375	19.2
Leigh Males				
35-44	86	243.0	135-360	11.6
55-64	53	249.0	125-380	15.0
75+	25	223.0	153-323	4.0
Leigh Females				
35-44	91	246.2	145-333	9.9
55-64	62	271.6	176-403	22.5
75+	32	281.8	167-390	34.0

(1970) and Howell (1970) report slightly lowered mean values with lower social class.

Associations

There have been several reports noting the variation of serum cholesterol levels in relation to some unifactorial genetic systems (Mayo et alia 1971,for example). Associations have been found between the ABO blood groups and the haptoglobin system and typical of such results are those quoted here from Corfu by Mayo in Figure (132). The Holy Island values are also given in this figure.

The ABO results are shown to exhibit the same type of trend in both series : the highest values with blood group A and less with O and less again with B blood group. The serum cholesterol values are greater in the Corfu population but they follow the same trend as the English series.

The haptoglobin 2-gene seems to be associated with higher cholesterol levels in both series despite variations in the magnitude of the means. The adenylate kinase isoenzyme results are included because there is fairly close genetic linkage between the ABO and AK loci. The adenylate kinase 2-gene seems to occur with higher serum cholesterol levels. The total numbers involved in the Holy Island series is very small and this may be a basis for differences in the mean cholesterol levels. This also accounts for the lack of significant differences between any of the island sub-populations mentioned here,this is due to the large standard deviations.

Figure (132)

Cholesterol values in Relation to Unifactorial Genetic Traits

Holy Island

ABO blood Groups	Number	Mean Cholesterol Levels
A_1	32	190.8
A_2	13	166.5
A_1+A_2	45	183.8
B	15	177.0
O	63	181.7
A_1B	2	195.0
Serum Haptoglobin Types		
1-1	21	178.8
2-1	45	181.0
2-2	54	189.0
RBC Adenylate Kinase Isoenzyme		
1-1	114	179.7
2-1 and 2-2	11	197.1

Corfu (from Mayo et alia 1971)

A	208	208.4
B	82	200.9
O	249	202.6
AB	33	194.8
Hp 1-1	63	193.7
2-1	258	200.1
2-2	236	211.1

Relationships

It is possible to select the individuals in the population who are in the long standing island group and those wives born elsewhere who have islanders' children living on the island. The coefficient of relationship has been calculated as a whole for this group by counting the number of genealogical steps between all the pairs of members. This is recounted in the first chapter of this thesis. It is therefore possible to subdivide those individuals with certain attributes in common and examine their exact degree of relationship. In this case the cholesterol results were divided into seven groups containing between eight and nineteen persons. For each group all possible pairs of relationships were examined. The total possible number of pairs in a group is an expansion of the formula $n(n-1)/2$. The form of the triangular matrix used is shown in Figure (133).

Figure (133)

Triangular Matrix

Individuals	A	B	C	D	E
A	-	1	2	3	4
B	-	-	5	6	7
C	-	-	-	8	9
D	-	-	-	-	10
E	-	-	-	-	-

Each individual may be compared with all others in the group once, by this method. For each small group it is possible to find a summated value (ΣR) dependant on the coefficient. This value will vary from group to group depending on the total number of possible pairs of combinations (z) and also on the fact that many relationships are duplicated or have even as many as five possible routes of relationship (x), all of which must be noted in this mode of computation. These are displayed in Figure (134). Here it is shown that the summated value

Figure (134)

Serum Cholesterol and the Coefficient of Relationship

Cholesterol values	Numbers per group	Summated R	z	x	r	r/lowest	r/Tr
under 99	8	0.2107	28	25	.0040	0	.19
100-139	11	2.2170	55	27	.0270	6.8	1.29
140-159	10	1.2830	45	33	.0164	4.1	.78
160-179	19	4.2976	171	110	.0153	3.8	.73
180-199	15	1.8619	105	68	.0108	2.7	.51
200-239	14	1.3826	91	33	.0112	2.8	.53
240 plus	12	1.6443	66	28	.0175	4.4	.83

$z = n(n-1)/2$

x = the total number of relationships

$r = R/z+x$

Tr is the total population value of r calculated earlier of R is divided by the values (z) and (x) to produce r. This is not a true coefficient of relationship, yet the value r is shown to vary widely in relation to the lowest value of r and also in relation to the total population value (Tr). These are displayed in the last two columns of Figure (134).

The significance of these results is not understood. Cholesterol values will vary as a result of several 'enviromental' factors including age and diet. In addition to this the varying figures for the relationships in the subgroups make it likely that some inherited factors are also playing a part. The values in Figure (134) demonstrate the basis of fluctuations rather than the features of the inherited component. Such interrelationships may be a contributory cause of the low island cholesterol means.

Part (u)

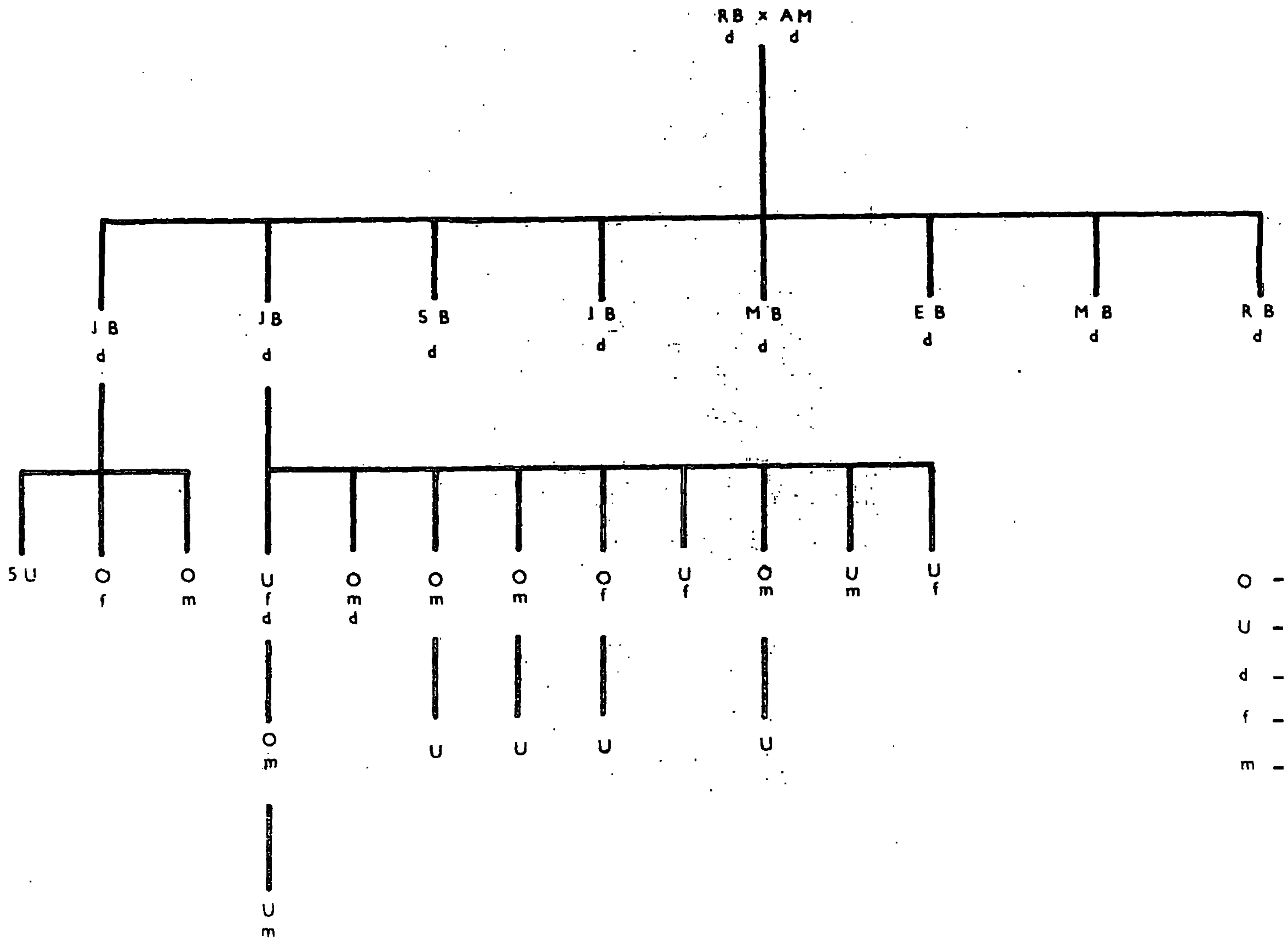
Premature Osteo-Arthritis of the Hip

One family on the island has a high proportion of hip disease amongst its members. In all the investigated cases the pathology was typically osteoarthritic. This is an unsatisfactory condition for a geneticist to deal with as the condition only appears in the late 40's and younger individuals may or may not be affected later in life. Those who manifest the trait are of both sexes and have a variety of occupations,none suggesting a professional cause. Also no firm records exist about the condition in earlier generations and the verbal accounts are difficult to interpret. It seems likely, however,that some of the earlier generations had this hip condition. No other joints appear to be affected. Many diseased hips have been recently replaced by prostheses. There are no close relationships between the two common ancestors RB and AM during the last four generations,although both belong to the core community of the island. The affected members of the community at the time of writing are shown in Figure (135) along with their major interrelationships. The likeliest mode of inheritance for this factor thus seems to be an autosomal dominant gene with less than complete penetrance.

There have been preliminary reports of premature osteoarthritis of the hip amongst some Zulu tribesmen by Wittman and Fellingham (1970). Here an enviromental aetiology is suspected but has still to be proved. There appears to be few other reports in the literature.

Holy Island FIGURE (135)

A Pedigree of Premature Osteoarthritis of the Hip



Key

O - Individual known to be affected

U - Individual known to be unaffected

d - dead

f - female

m - male

Part (v)

Summary of Chapter Three

This chapter has dealt with some of the data obtained from the medical tests on the living Holy Island population. The screening tests used were those readily available to the author and are described in part (q). The results are briefly recorded in part (q) and are then discussed. Two sets of exceptional results are the serum levels of uric acid and cholesterol. In addition many of the traits exhibit large standard deviations. The various problems of interpretation are discussed in part (r). Some further analyses are then displayed for the serum uric acid values in part (s) and serum cholesterol values in part (t). The results of both these entities are unusual and possible causes are discussed. These parts tend to highlight a dearth of knowledge rather than give any acceptable reasons for the high serum uric acid and low cholesterol levels. Additional analyses in part (t) centre around the reported associations of serum cholesterol with the ABO,adenylate kinase and haptoglobin phenotypes. A trend in variation is demonstrated which is not statistically significant. The possibility that interrelationships have influenced the cholesterol results is also investigated in part (t). A method whereby pairs of individuals may be assessed by their relationships and by their cholesterol results is given. This subject is also mentioned in parts (g) and (k). Here again only crude values are used to provide some comparative data,nevertheless it may still be seen that some subgroups of interrelationships vary from others by factors of 2,3,4 and 6. The significance of this is not understood but it is considered that further investigations into this aspect would be justified.

Finally this chapter includes a brief report on an apparently inherited trait in the island population; premature osteoarthritis of the hip.

This chapter is less detailed than the preceeding ones and takes a thorough look at only two attributes; serum uric acid and cholesterol levels. It is thought that further investigation is not justified due to the size of the community and the heterogeneity of many of the factors.

SYNTHESIS AND SUMMARY

This study was undertaken with three aims in mind. Firstly to investigate the biology of a geographically isolated group in England, secondly to initiate a small study so that the techniques and analyses may be used in larger studies and thirdly, in an attempt to obtain results from a complete population. The three chapters of this thesis reflect these aims and also account for the major interests of the author.

The first chapter deals with a variety of demographic topics, historical and contemporary which are of use in understanding the formation of the population at different times. There are sections on the secular trends (c), the nineteenth century census returns (d), the parish marriage data (e), the production of children (f) and the living population (g). Part (b) introduces the demographic methods used in chapter one and outlines the method of population subdivision used in all the chapters.

The second chapter is mainly devoted to recording the results of the non-medical traits collected from the living population. They are subdivided as unifactorial (part (k)), multifactorial (part (l)), and others (part (m)). This final part includes traits whose inheritance is not known or is in doubt. In addition to the results, comments and analyses are also included in this chapter. They are mostly maintained at a superficial level, whilst part (n) is devoted to a consideration of more general topics which could be of relevance to the understanding of the results.

Chapter three is the shortest and completes presentation of the investigation on the living island group. Here the medical results are reported. Most of the results are given in part (q) whilst parts (s),(t) and (u) complete the data by dealing more specifically with uric acid,cholesterol and premature osteoarthritis of the hip.

All these results and many of the conclusions are obscured by two features; the small size of the population and the lack of suitable techniques by which this study may be compared with others. Methods are suggested to overcome this. These are not analysed in great detail and include the more sophisticated use of surnames and the use of the 'relatedness' of the sample members. These two topics are mentioned in each chapter and serve,in this respect,as links between the three major sections. The chapters are also linked by a consideration of genetic attributes and the ways the population may be subdivided (see part (b)).

The main conclusion of this study is that the island population is different from other groups genetically,demographically and medically. This may be demonstrated by a study of the census material in part (d). Here the island is contrasted with the nearby mainland and shows differences in the population turnover. Marriages also differ on the mainland when compared with similar statistics for Holy Island (part (e)). Parts (k),(l),(m),(q),(s) and (t) also contrast data from Holy Island with other groups; the comparative data are either from Northumberland or failing this the nearest point from which data are available. Some island data are seen to be similar to the compared groups,many comparisons are different but not statistically so whilst others are statistically significantly different. The community,in toto,is different from the contrasted populations in most of the reported aspects.

The main contention of this study is that although the island population is unique in its results,this is not an abnormal or unique phenomenon. Furthermore,it is possible that each generational group on Holy Island was similarly unique; this may at least be postulated from the historical demographic evidence presented here and summarised elsewhere (Cartwright 1973). This contention implies that other small population units will also be unique in their attributes when compared to other samples. Evidence to lead to this is drawn mainly from an analysis and interpretation of the island demography. There is less supporting evidence from other studies to suggest that they are also indicating unique demographic and hence genetic histories. Galt's study of South Scottish populations indicates wide variation in the demography of different parishes. Surname distribution could be interpreted as indicating a perpetuation of marked demographic and genetic heterogeneity. Razzell's paper on non-representation of census material in the parish records may be seen as a crude countrywide index of population movement : those not in the parish records being more likely to have been migratory,again demonstrating wide variability throughout England.

The paradox between abnormality and normality,the uniqueness of the individual and the uniquenessof the population,is only likely to be resolved when other similar studies have been done involving societies with long and detailed population records. Until then and until new statistics have been devised to cope with the data presented here,the significance of this thesis will remain obscure.

Appendix One

Coefficient of Relationship of Each Member of the Holy Island Community

The coefficient of relationship of the individual members of the Holy Island population was calculated from the following tables of N values. The first column is a number representing each islander. The remaining columns indicate the number of occasions each N value is used to relate this person to all the other island members. N values record the number of genealogical steps between related people. The last row of figures in this appendix show the summations of the number of occasions each N value is used. As each person has been treated separately each interrelationship has been calculated twice. Further details will be found in part (g).

No. of each individual	1	2	3	4	5	6	7	8	9	10	11	12
1	3	4	19	26	40	6	4					
2	3	2	3									
3	2	4	1	3	15	8	2					
4		2		13	8	1						
5	2	4	1	3	15	8	2					
6	3	4	19	26	40	6	4					
7	4	4	19	26	40	6	4					
8	3		9	9	14	10	28	25	27	9	1	2
9	3		9	9	14	10	28	25	27	9	1	2
10	3	2	11	6	14	10	28	25	27	9	1	2
11	3	2	11	6	14	10	28	25	27	9	1	2
12					1			2	1			
13	3	4	1	7	3	16	19	14	14	4		
14	1	5	4	16	8	14	7	16	9	1	2	
15	2	2	6	7	16	33	34	25	12	4		
16	4	11	6	14	16	28	25	27	9	1	2	
17	4	5	20	8	14	7	20	11				
18			1									
19	2											

Individual	1	2	3	4	5	6	7	8	9	10	11	12
20	2											
21	4	5	20	8	14	7	20	11				
22	4	5	20	8	14	7	20	11				
23	3	1	3	16	42	32	14	10	5			
24	5	5	6									
25	3	9	11	4	4	24	15	15				
26	3	9	9	14	10	28	25	27	9	1	2	
27	7	7	15	8	14	7	20	11				
28	1		7	10	7	13	16	13	13			
29	2	2	3	16	42	32	14	10	5			
30			2	7	18	8	23	14	13			
31	1		7	8	30	22	21					
32	2	2	3	16	42	32	14	10	5			
33	1	3	14	5	18	10	14	12	8			
34	1			7	8	30	22	21				
35	3	4	19	26	40	6	4					
36	1											
37			7	2	19	25	28	10				
38	2	1	9	6	9	12	10	7				
39		2	5	10	36	41	78	43	29	12	8	

40			9	26	47	31	15				
41	4	4	7	13	10	13	2				
42		2	5	10	36	41	78	43	29	12	8
43		9	6	21	26	40	6	4			
44	3	4	7	4	4						
45	2	1	3	23	31	65	41	29	12	8	
46	2	1	9	6	9	12	10	7			
47		6	13	4							
48	3	5	6	13	10	13	2				
49	1	3	9	22	21	24	18	20	16	7	
50	3	4	7	13	10	13	2				
51	2		3	9	22	21	24	18	20	16	7
52	2	3	8	14	17	14	13	2			
53	4	2	1								
54	4	3	4	5	30	22	21				
55	1	6	5	5	5	30	22	21			
56	1	6	5	5	5	30	22	21			
57	2	8	7	27	16	44	29	41	11		
58	4	4	20	8	14	7	20	11			

No.	1	2	3	4	5	6	7	8	9	10	11	12
59	4	3	7	8	30	22	21					
60	4	3	7	8	30	22	21					
61	5	3	7	8	30	22	21					
62	4	3	7	8	30	22	21					
63	2	4	1	3	15	8	2					
64			7	9	7	5	3					
65		1	1	2	3							
66	2	4	1									
67	2	4	1									
68	2	3	3									
69	3	3	6	18	11	11	29	18	15			
70	5	6	11	4	4	24	15	15				
71	2		7	7	7	5	3					
72	3	3	6	18	11	11	29	18	15			
73	1			4	2	6	5	1	2			
74	2		4	2	6	5	1	2				
75	2											
76	1				1	5	4					

No.	1	2	3	4	5	6	7	8	9	10	11	12
77	2		3	3	2							
78	1	1	3	3	2							
79	2		12	12	15	5	18	18	9			
80	2	2		15	15	17	5	18	18	9		
81	2	2	1		10	12	8	6	2			
82	2	2	1		10	12	8	6	2			
83	2											
84	1				1	5	4					
85	2	2	15	15	19	18	29	29	15			
86	3	2	12	12	15	24	23	18	8			
87	2	3	4	27	27	34	32	52	47	23		
88	3	2	12	12	15	14	23	18	8			
89	2		3	4	27	27	34	32	52	47	23	
90	2		3	4	27	27	34	32	52	47	23	
91	1		7	10	7	13	16	13	13			
92	2	2	15	15	19	18	29	29	15			
93	3	4	12	5	18	10	14	12	8			
94	4	4	1	7	3	16	19	14	14	4		
95	3											

No.	1	2	3	4	5	6	7	8	9	10	11	12
96	2	3										
97	6	2	4	12	12	17	13	28	27	15		
98	6	4	12	12	17	13	28	27	15			
99	3	2	4	12	12	17	13	28	27	15		
100	2	2	4	12	12	17	13	28	27	15		
101	4	11	6	14	10	28	25	27	9	1	2	
102	1											
103	3											
104	1		7	5	19	27	28	6				
105		1	16	23	22	24	43	44	14			
106	3	4	13	10	26	22	45	38	55	36	16	2
107	3	4	13	10	26	22	45	38	55	36	16	2
108	2	2	2	4	12	12	17	13	28	27	15	
109	2		5	5	29	32	28	7				
110		1	1	1	2	3						
111	3	6	13	4	4	24	15	15				
112	1	3	5	13	4	4	24	15	15			
113	5	5	13	4	4	24	15	15				

No.	1	2	3	4	5	6	7	8	9	10	11	12
114	2											
115	1	3	5	13	4	4	24	15	15			
116	2		5	5	29	32	28	7				
117	2		5	5	29	32	28	7				
118					1		1	4				
119	1		12	12	15	5	18	18	9			
120			3	5	4							
121	3					4	6	10	2			
122	2	1	9	6	9	12	10	7				
123	3					4	6	10	2			
124	2	2	1		10	12	8	6	2			
125			3	2	8	2	4					
126	3					4	6	10	2			
127	3					4	6	10	2			
128	4	1				3	15	7				
129	2		1									
130	4	4										
131		3	3	11	8	12	12	10	7			

No.	1	2	3	4	5	6	7	8	9	10	11	12
132	2	2	2	2	3							
133	3	4	7	4	4							
134	3	1	4	7	4	4						
135	3	1	4	7	4	4						
136	1	3	2									
137	3	5										
138	1	3	2									
139	2		3	2								
140	2	3	4	4								
141	2	2	1		10	12	8	6	2			
142	4	1				3	15	7				
143	1			4	2	6	5	1	2			
144	4	1	4	1	7	3	16	19	14	14	4	
145	4	1	4	1	7	3	16	19	14	14	4	
146	4	1	4	1	7	3	16	19	14	14	4	
TOTALS	1	2	3	4	5	6	7	8	9	10	11	12
	333	339	820	1046	1747	1803	1987	1509	982	419	140	12

The odd numbers indicate that a few reciprocal relationship routes have been omitted.

Appendix Two

The Percentage Contribution of New Couples who Integrate into the Population of Holy Island .

This appendix is a cohort analysis demonstrating that each cohort group consists of a random assortment of descendants from only 96 couples. The column headed 'total' gives the absolute figures for the number of children produced each cohort decade and so enables the real numbers of descendants to be computed if desired. The percentages are rounded off to the nearest whole number and are in some cases as high as 60%. The numbers along the top of the sheets are the code numbers of the couples involved. The earlier and later cohorts are less accurate than the bulk of the work, the former through the inadequecies of the registers, the latter as the cohorts are still being expanded by new births.

PERCENTAGE CONTRIBUTION OF OFFSPRING TO EACH COHORT BY NEW COUPLES ENTERING THE ISLAND COMMUNITY

COHORT	TOTAL	Number of new couples 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
1	7	29 29 14 29
2	11	- - - - 45 27 27
3	22	32 - - - - - - - 5 23 18 9 9 5
4	34	- - 6 - - - - - - - - - - - 9 12 12 15 21 15 12
5	48	- 4 - 8 - 13 13 17 - 6 13 - 8 - - - - - - - - 6 8 4 8 13
6	37	14 - 5 - - - - - 11 - - - - - - - - - - - - - - - - 8 3 30 3 5 5 8 8
7	134	4 10 - - 4 - - - - 1 - 4 - - 10 3 6 4 1 7 8 1 3 6 - - - - - - - - - 3 3 6 2 5 7 4 2
8	92	- - 10 3 - 14 7 - - 3 6 - 3 4 - - 8 5 8 1 - - - 10 7 - 4 - - 5 - - - - - - - - - - - - 8 1 1 7 4
9	77	- 3 - - 2 3 4 9 1 - 4 - - - - - - - - - 3 - 4 - 6 2 - - - - - 8 - 8 4 - 4 - - - - - 4 - - - - - - 6 10 9 5 3 8
10	150	- - - - 1 1 3 7 - - 3 7 - - 7 5 2 - 5 1 9 - 3 3 - - - 5 - 3 - 7 - - 8 9 6 6 6 5 6 - - - - - - - - - - - - 6 4 3 1 3 1
11	107	- 17 - 4 - - - - - - - - 4 - - - 10 - - 4 - - 2 8 - 6 - 4 8 2 - - 3 - - 1 - 9 - - - - - 7 6 3 6 - 3 - - - - - - - - - - - - - 8 5 5 3 7
12	105	- 11 24 - - 6 - - - - - - - 1 - - - 1 3 6 - 4 - 4 8 - 1 - 7 - 10 - - - - 8 - - - 5 - 4 - - - - - - - 6 2 3 - - - - 5 - - - - - - - - 2 3 5
13	84	- - - - - - 11 7 - - 11 7 - - - - - - - 5 1 7 - - - - - - 6 - - - - 11 5 - 5 - 1 - - 11 - - - - - 8 - - - - 2 4 - - - - 7 10 - 7 - 2 - - - - 1 8 6
14	197	- 19 3 - - - - - - - - - - - - - 15 - 7 1 3 4 11 15 6 8 - 2 5 11 3 2 - - 4 9 - 4 4 4 - - 4 - 4 - - 4 - 4 2 - 2 - 8 3 - - 5 3 7 6 - - - 3 - - - 3 1
15	145	- 8 1 4 - - - 1 - - - - 1 4 4 - - - - 4 3 6 1 4 - 4 - 2 4 4 - - 8 - - - 4 6 4 11 - - - 4 1 5 - 2 - - 6 - - 3 - 2 - 3 - 3 1 6 - - - 6 6 2 1 - 3 - - 2 5
16	116	- 4 1 - - 11 9 - - - 9 - - - - - - - 6 - - - 4 4 3 3 - 3 2 4 4 - 9 6 7 10 - - - 3 9 - - - 7 - - 7 - 3 - - 3 - - 8 7 16 - 6 - - 7 6 - - 9 - - - 2 - - 2 3 2
17	111	- 14 1 - - - 10 - - - 10 - - - - - - 6 - 5 - - 6 12 18 - 6 - - - 12 - - 7 - 8 10 - - 5 10 10 - - - 8 - 5 8 - - - - 4 7 - - - - - - - - - - - 1 - 7 - 2 - 3 - 7 - - 1 - - - 6 7
18	117	- 17 4 4 - - - 3 - - - 3 4 1 - - 14 1 8 - 3 - 9 9 1 11 1 4 - 9 - - - 3 5 8 4 7 4 - - - 5 4 1 - - 1 6 1 1 4 - 9 14 - - - 1 - 6 3 - 6 3 - - - 2 4 - 11 7 3 - - - - - 2 4
19	91	- 4 - 1 - - 4 7 - - - 7 - 1 - - - - 2 - 6 4 - 2 7 9 3 - - 4 8 7 14 - 1 - 2 12 1 1 - 11 7 1 - - 1 - - 1 5 3 - 2 - - - 15 - 4 - 1 4 1 - - 1 - 2 - - - - - - - 5 10 - - - - -
20	74	- 23 - - - 1 12 - - - 12 - - - - - - 14 - - 11 - 15 16 28 - 15 - - - 16 10 - - - - 10 - - - - 12 - - - - - - - - - - - 1 11 - - 1 - 9 - 11 - - - 8 - 4 9 12 - 1 4 - - - - - 7 9 - - - - 9
21	60	- 58 - - - - - 10 - - - 10 - - - - - 42 - 10 - 10 - 3 3 3 13 - 3 - 3 - - 7 - - - - - 17 - - - - - - - - - - 10 42 3 - - - - - 42 3 - - - - - 10 - 2 20 - - - - - - 17 - - 27 - - - - - 18 15 - -
22	46	- - - 9 - 2 - - - - - - 9 - - - - - - 24 - - - 7 7 4 7 - 13 - 7 17 - - 7 9 20 9 - - 13 - - - - - - - - - 9 - - - - - - 33 - 7 - - - - - - - 7 - - 7 - - - - - 2 15 - - - - - - - - - 22 7
23	87	- 22 - - - 7 3 - - - 3 - - - - - - 18 - 8 1 - 15 3 26 - - - - - - 3 10 - - - - 2 - - - 1 3 - - - - - - - - - - - - 10 - 3 8 - 2 - 10 - - - 3 - 1 2 2 - - - - - - 7 14 - 15 - - 1 10 - - 6 3 1
24	86	- 36 - - - - 1 8 - - 1 8 - - - - - 31 - 6 - 8 13 12 23 - 33 - - - 12 8 - 9 - - 7 - - 5 - 1 - - 7 - - - - - - - - - - - 9 19 1 - 7 - - 2 - - 7 - - 7 1 - 7 - - 30 - - 8 13 9 7 - - 5 - - - -
25	100	- 25 - - - 7 23 8 - - 23 8 - - - - - 18 - 12 - 8 - 23 23 - 21 - - - 23 22 - 12 - - 14 - - - 14 23 - - 6 - - - - - - - - - - 2 8 25 12 - 10 - 2 7 - - 6 - - 10 13 - 6 - - 12 - 6 - - 12 6 1 - - 5 - - - - 3 7
26	154	- 20 - - - 4 10 - - - 10 - - - - - - 12 - 6 - - 10 10 25 - 10 - - - 10 6 - 1 - - 2 - - - 2 10 - - 1 - - - - - - - - - - 14 - 8 6 - 2 - 14 6 - - 3 - - 2 10 - - - - 5 14 16 - 10 - - 7 1 - 6 8 8 1 - - 1 2
27	48	- 15 - - - - - 17 - - - 17 - - - - - 6 - 2 - 17 6 - 6 - 17 - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - 17 6 - - - - - - - - - 6 - - - - - 2 - - 6 - - 4 6 - 10 - - 23 - - - 10 4 10 - - 6
28	159	- 31 - - - 6 11 - - - 11 - - - - - - 32 - 6 - - 10 11 28 - 11 - - - 11 6 - 8 - - - - - 1 - 11 - - 7 - - - - - - - - - - 10 - 19 6 - - - 10 8 - - 1 - - - 11 - 6 - - 16 13 10 1 10 8 1 6 - - 3 6 6 - - - 6 4 -
29	76	- 25 - - - 4 22 - - - 22 - - - - - - 24 - - - - 5 22 30 - 22 - - - 22 1 - 16 - - 1 - - - 1 22 - - 3 - - - - - - - - - - 3 1 25 - - 1 - 3 5 - - 1 - - 1 21 - 3 - - 18 8 3 1 5 21 1 - - 1 4 - - - 1 - - - 7 11
30	123	- 11 - - - 2 8 11 - - 8 11 - - - - - 15 - 8 - 11 6 8 18 - 18 - - - 8 8 - 1 - - 1 - - - 1 8 - - 8 - - - - - - - - - - 13 7 5 8 - 1 - 13 - - - 1 - - 1 7 - 8 - - 8 20 13 1 6 1 1 18 - 1 2 20 20 - - - 9 4 2 - 1
31	129	- 27 - - - 7 16 16 - - 16 16 - - - - - 23 - - - 16 9 16 37 - 32 - - - 22 - - 7 - - - - - - - 16 - - 8 - - - - - - - - - - 9 20 15 - - - - 9 - - - 6 - - - 16 - 8 - - 15 14 9 - 9 8 11 7 - - 1 7 7 - 4 4 4 5 4 16 - 2 1
32	105	- 38 - - - 1 7 8 - - 7 8 - - - - - 36 - 2 - 8 10 7 15 - 14 - - - - 2 - 25 - - - - - - - 7 - - - - - - - - - - - - - 13 - 27 2 - - - 13 7 - - 1 - - - 7 - 7 - - 25 11 9 - 9 10 1 4 - 8 15 7 7 - - - 10 1 1 - - - -
33	95	- 9 - - - - 27 7 - - 27 7 - - - - - 14 - 14 - 7 6 27 60 - 35 - - - 26 14 - 6 - - - - - - - 27 - - 2 - - - - - - - - - - 1 1 8 14 - - - 1 - - - - - - - - 27 - 1 - - 7 21 1 - 8 6 3 17 - - - 14 14 - - 3 14 1 1 - 6 9 -
34	49	- 2 - - - 10 41 25 - - 41 25 - - - - - 6 - - - 25 - 41 37 - 53 - - - 27 - - - - - - - - - - 27 - - 6 - - - - - - - - - - 10 29 2 - - - - - 10 - - - - - - - - 25 - 6 - - 6 33 10 - - - - 27 - - - 27 27 - - - 12 2 22 12 - - 8
35	18	- 22 - - - 6 - 11 - - - 11 - - - - - 44 - - - 11 - - 6 - 11 - - - - - - 22 - - - - - - - - - - 22 - - - - - - - - - - 11 11 44 - - - - 11 - - - 6 - - - - - - - - - 44 17 11 - - 22 6 6 - - - 6 6 - - - 11 22 - - - 6 -
36	26	- - - - - - 23 46 - - 23 46 - - - - - 8 - 15 - 46 - 23 61 - 23 - - - 23 15 - 4 - - - - - - - 23 - - 4 - - - - - - - - - - - 23 4 15 - - - - - - - - - - - - 23 - 4 - - 8 27 - - - 4 - 23 - - - 23 23 - - - - - 23 - 4 23 12
37	26	- 8 - - - 8 8 8 - - 8 8 - - - - - 8 - 8 - 8 - 8 46 - 15 - - - 8 8 - 4 - - - - - - - 8 - - 4 - - - - - - - - - - - 8 4 8 - - - - - - - - - - - - 8 - 4 - - 8 12 - - - 4 8 19 - - - 19 19 - - 8 23 - 8 8 4 19 15
38	48	- 4 - - - - - 15 - - - 15 - - - - - 10 - 17 - 15 - - 29 - 8 - - - - 17 - 10 - 4 6 10 17 - - - 4 - - - - - - - - - - - - - 10 33 6 - - 10 2 6 - - - 6 6 - - 2 8 - - 4 8 10 -
39	10	- 10 - - - - 10 20 - - 10 20 - - - - - 10 - - - 20 - 10 20 - 20 - - - 10 - - 10 - - - - - - - 10 - - - - - - - - - - - - - 20 10 - - - - - - - - - - - - - 10 - - - - 10 10 - - - 10 - 10 - - - 10 10 - - - - - 10 10 - - 60
40	18	- 11 - - - - - - - - - - - - - - - 11 - - - - - - - - - - - - - - - 11 - 11 - - - - - - - - - - - - - - - - - - 11 - - - - - 11 - - - - - - - - - - - - - - - - -

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