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A Simple Survey Method for Assessing Tree Regeneration in Woodlands

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Introduction

The following paper, which deals with an investigation that was carried out in North Wales in 1966, was originally written as a "spring cleaning" exercise prior to the author's transfer from the Conservation Branch at Bangor to Merlewood Research Station. It has been little altered in its role as a Merlewood Research and Development Paper and as such should be treated as a case history rather than an investigation of regeneration in North Wales woodlands. The emphasis is on the methods of measurement of regeneration and site parameters and their subsequent interpretation in relation to an actual example. The survey described will be repeated in the same woods in 1969 and probably again at 3-5 year intervals thereafter. Ultimately a formal scientific paper will be written on the results which will also provide much needed information on the management of the woods in question.

The methods described are extremely simple, objective, reproducable and require no elaborate or costly equipment. Field sampling can be carried out by anybody who can identify the tree seedlings and ground cover categories. The laboratory work of sectioning and ageing is more difficult but the necessary skills are soon acquired.

The Woodland Habitat Team will be making extensive use of these methods in the coming year and will be incorporating a number of new measurements. These may include chemical analyses of soils, seedlings and vegetation, examination of seedling leaf areas and root systems, light measurements and improved methods of measuring ground cover and vegetation types. Such developments will be reported at an early date. The ultimate aim is to be able to express the regeneration potential of a site (i.e. species, growth rate, time sequence etc.) by means of a few relatively simple measurements.

Survey of Regeneration in North Wales Woodland Reserves - 1966

Object

To study the density and age distribution of tree seedlings in Woodland Reserves in North Wales. It was also hoped to relate this information to other factors such as the history and intensity of grazing, ground vegetation, slope and tree canopy both type and density.

A feasibility trial of the method used for the determination of age distribution was carried out at Coed Gorswen in August 1964 (H. Bartlett - Student Survey Report).

Methods

(1) Field

Field sampling was carried out in late July and early August 1966. The density of seedlings and the samples for age determination were obtained from $\frac{1}{2}$ sq metre quadrats (50 x 100 cms). Random lines were taken up or down the slope within the area to be sampled and samples were taken at regular intervals (5-20 yards according to the coverage required). What were thought to be typical areas were chosen for sampling and no attempt was made to sample the entire wood. Sampling areas were usually about 5 acres, but as little as 1 acre was used where it was desirable to keep interference with natural seedlings within a small area. The rectangular quadrat was orientated with its long axis at right angles to the contour (see Shaw 1968a). Normally 100 x $\frac{1}{2}$ sq metre quadrats were taken in each sample area but owing to the extremely high density of seedlings in one area only 25 x $\frac{1}{2}$ sq metre quadrats were taken. In another area the seedling survey was combined with a survey of tree cover and, owing to the difficult nature of the ground, only 78 x $\frac{1}{2}$ sq metre quadrats were taken.

Each seedling within the quadrat was dealt with individually (wherever possible) and the following information was obtained:-

(a) Species.

(b) Height - from ground level to live tip (in cms to the nearest 0.5 cms).

(c) A 10 cm diameter circular quadrat was placed around each seedling and the cover % of vegetation (including litter and bare ground) was recorded by visual inspection.

(d) The seedling was then pulled up (except in the case of first year seedlings which could often be identified *in situ*) and individually labelled.

(e) The seedlings were then brought into the laboratory for age determination by sectioning and/or counts of terminal bud scars. Where seedlings were not to be worked on immediately they were put into a sealed polythene bag and placed in deep freeze.

Other information recorded at the site of each quadrat, whether or not it contained seedlings, was:-

(i) Canopy species - i.e. species vertically above quadrat or nearest to this.

(ii) Canopy % - estimate by eye.

(iii) Slope of ground - in degrees by eye.

(2) Laboratory

The age determination of seedlings was usually carried out by sectioning the base of the stem with a razor blade. The absolute base of the stem or hypocotyl was avoided as ring growth is usually less pronounced in this region. Quite thick sections were often found to show the rings much better than the thin type more commonly used for anatomical work. The sections were usually mounted dry on a glass slide and examined under a binocular microscope using magnifications of X 20 to X 60. Illumination of the section from above was found to be best and low oblique lighting (ca. 15^{o}) was often advantageous. No anatomical stains were used in the present study but there may be a potential for developments in this field.

On the whole the methods of seedling age determination were thought to be quite satisfactory for the required purpose. The following consists of brief notes on the most common species encountered and the ease or difficulty with which ageing was accomplished.

(a) Oak

The ring porous wood of this species showed clearly defined growth rings except in the case of slow-growing, highly suppressed seedlings, i.e. those growing under extremely low light intensities. Unfortunately such seedlings can survive on their food reserves for up to about 4 years and produce some difficulty, and therefore inaccuracy, in the ageing of seedlings up to this age. Terminal bud scars provide no assistance but stem breaks, as identified by changes in bark texture, can often be used in conjunction with the interpretation of growth rings. More rapidly-grown oak seedlings, and those which survive to greater age, are easily and accurately aged by growth rings. First year seedlings can be easily identified in the field by the colour and texture of the shoot and the presence of plump cotyledons at the base of the stem.

(b) Birch

In contrast to the adult tree, the ring growth of seedling birch is quote well marked in section. Small suppressed seedlings present some difficulty but usually do not survive long. Bark texture provides some assistance in distinguishing between slow-grown 1st and 2nd year seedlings.

(c) Rowan

This species is rather similar to oak but as the food reserves of the seedling rowan are much smaller they do not usually survive long enough under adverse conditions to present ageing difficulties. Again bark texture is a useful guide with 1st and 2nd year seedlings.

(d) Ash

This species presented more difficulties than all the others put together. Slow-growing, highly suppressed seedlings often survive for a number of years and are extremely difficult to age. Terminal bud scars and bark provide little or no help. As a result of these difficulties, the age distributions of ash seedlings up to 3, or possibly 4 years, are probably somewhat "smoothed", but inaccuracies of ± more than 1 year are extremely unlikely. One suspicious feature of the results obtained is the general lack of 1st year seedlings which leads to the assumption that either 1965 was a very poor ash seed year or there has been some confusion between 1st and 2nd year seedlings. Well-grown ash seedlings present little difficulty and the ageing of seedlings over 4 years is probably very accurate. Fairly thick sections, dry mounting and oblique lighting are essential to the interpretation of ash.

(e) Sycamore

Ring growth is usually quite well marked but the prominent terminal bud scars produced by this species provide an extremely rapid and accurate method of ageing. Only where the main stem of a seedling has been broken at some time is it necessary to resort to section cutting.

(f) Holly

Despite its evergreen habit the ring growth of this species always seems to be well marked. The reason for this probably lies in the extreme shade tolerance of holly and its consequent ability to make satisfactory growth under low light intensities.

Too few samples of the other species encountered were examined for any useful comments on them to be made.

Results

The following is a list of the woods, all of them National Nature Reserves, which were included in the survey. The date of fencing against domestic stock, or lack thereof, and the present status is also indicated.

Name of Wood	Date of Fencing	Present Status of Grazing
Coed Gorswen	Summer 1960	Virtually nil
Cwm Glas Crafnant (fenced woodland enclosure)	Summer 1961	Slight
Coed Dolgarrog (2 sample areas)	Summer 1960	Slight-moderate
Coed Cymerau (2 sample areas)	Spring 1963	Area 1 - Nil Area 2 - Slight-moderate
Coedydd Maentwrog	Unfenced	Very high
Coed Camlyn	Autumn 1960	Slight-moderate
Coed-y-Rhygen	Unfenced	High
Coed Ganllwyd	Unfenced	High

This gives a total of 8 woods and 10 sample areas. Maps showing the location and approximate extent of the sample areas within the Reserves are held at the Bangor Research Station.

The density of tree seedlings is summarised in Table 1. No standard errors have been calculated to date but the statistics of the type of sampling has been fully discussed elsewhere (Shaw 1968a). The percentage distribution of the most common seedling species are shown in Figs. 1-6, size of sample is given in brackets ( ). Height growth of oak in five of the Reserves is shown in Figs. 7-11 and that of ash in Coed Gorswen in Fig. 12. Height growth of holly is shown in Fig. 13 and a comparison between the age distribution of ash and sycamore in Gorswen in 1964 and 1966 is shown in Fig. 14.

Discussion

(1) Seedling Density

By far the highest density of tree seedlings was recorded in Coed Gorswen, the regenerating species being mainly ash and to a lesser extent sycamore. The wood with the second highest density of seedlings, Dolgarrog 1, had only about 5% of that at Gorswen and different species, the most common ones being birch, oak, sycamore and holly. Regeneration at Cwm Glas Crafnant was predominantly ash but again with only a fraction of the density at Gorswen.

The exceptional number of seedlings at Coed Gorswen can probably be accounted for by the general character of the wood which is that of a lowland, base-rich oakwood.

There has also been a history of low grazing pressure since about 1960 which has permitted the density of seedlings of the freely seeding ash and sycamore to build up rapidly.

Both Dolgarrog and Crafnant have some degree of base-rich influence in their soils and it is interesting to note that seedling density in these woods is of a rather higher order than in those on more acidic soils, e.g. Cymerau, Maentwrog, Camlyn. Crafnant also has a very open tree canopy. On the other hand, Coed Ganllwyd also has a base-rich influence but had the lowest seedling density of all the areas studied. This latter case can probably be attributed to the dense tree canopy and high grazing pressure.

The density of oak seedlings was highest at Dolgarrog 1 and in the two Cymerau samples. Several of the remaining areas showed a consistent density of about 0.25 seedlings/sq metre (or about 1 seedling every 4 sq metres). Three areas had very few or no oak seedlings. The reasons for low seedling densities at Ganllwyd have already been discussed and in addition little is known about acorn production in this wood. The absence of oak seedlings in Crafnant is easily explained by the fact that there are only two rather stunted adult oak trees at one end of the fenced enclosure. The explanation for the marked difference in oak seedlings between Dolgarrog 1 and 2 is not so obvious. Oak is the dominant tree in the area of Dolgarrog 2 and individually the trees are quite well grown and vigorous but it is suspected that they do not produce such large crops of acorns as the trees in Dolgarrog 1. Altitude may be having some influence here as Dolgarrog 2 lies at about 1,000 ft O.D.

The most ubiquitous of the seedling species was rowan, appearing in all the samples, but regenerating most freely at Coedydd Maentwrog. Birch was also present in all but Gorswen. Ash and sycamore were limited to woods in which there was a seed supply. The presence of holly seedlings in several of the woods is worthy of note as this is probably the most shade tolerant of all the species recorded. Holly is almost certainly very adversely affected by the winter grazing of sheep but their recent enclosure from the woods may have permitted an increase of this species. It is suggested that the continued exclosure of sheep may lead to the development of an understorey of holly similar to that occurring in sessile oakwoods in Western Ireland. Although not recorded at the intensity of sampling employed in the present survey, holly was also present in serveral other woods and notably at Coed Cymerau where seedlings have been appearing widely since fencing. The other potential understorey species, hazel, does not seem to be regenerating so freely.

Age Distribution

(a) Oak

Of the woods investigated Coed Camlyn is immediately seen as the exception, with very few young oak seedlings but with a high density of "seedlings" up to nearly 20 years of age. Coed Camlyn also shows the same type of age distribution for birch and to some extent rowan. The most obvious explanation for this condition is probably an "event" - a thinning or possibly a fire or both (grazing has almost certainly been continuous) - which occurred about 20 years ago and which stimulated regeneration for a number of years. Local enquiries may reveal the nature of this "event". Some of the birch regeneration has grown sufficiently to form an understorey in parts of the wood and locally a few trees may even attain a position in the main canopy in the future. In general the oak seedlings have not grown so well as the birch and the tallest recorded in the present survey was only 78 cms high whereas the larger birch were around 150 cms and others of the same age were too large (> 3 metres) to appear in the quadrats.

Apart from the two Cymerau samples most of the other oak seedlings were under 4 years old (Dolgarrog 1 had a small proportion of older seedlings). In Cymerau there were quite a number of older seedlings up to about 8 years old. The known good seed year of 1964 was well indicated by the high density of 2nd year seedlings in several of the distributions (Dolgarrog 1, Cymerau 1 and 2 and Rhygen) and the other known good seed year of 1962 was also in evidence at Cymerau.

(b) Birch

The unusual age distribution of birch at Camlyn has already been discussed in some detail and apart from this only Cymerau 1 and 2 (also Crafnant) showed any birch seedlings over 3 years old. In Dolgarrog 1, with the highest density, 98% of the birch seedlings were in their 1st year.

(c) Rowan

There is little pattern in the age distribution of rowan seedlings, the production of which seems to vary quite considerably from year to year (good and bad seed years?). Quite a few older rowan seedlings were present, e.g. Dolgarrog 1 and Cymerau 1, and in some more open parts of Cymerau (not included in the present study) rowan seedlings are growing extremely rapidly and look as though they may form an understorey in places. However, in Maentwrog with the highest density of rowan seedlings, the age distribution was limited to the first 4 years.

(d) Ash

At Gorswen, with the highest density of ash seedlings, there was a wide age distribution, being continuous from the 1st up to the 10th year with an extended peak in the 2nd to 5th years. First year seedlings were rather low which, as already discussed, may be due to some extent to ageing difficulties or more likely to the fact that there was a poor crop of ash seed in 1965. By contrast the age distribution at Crafnant seems to be related to the date of fencing (summer 1961 - prior to which there was extremely high grazing pressure) with a peak in the 4th year (1962 - the year after fencing). After 1962 there was a steady decline in the production of ash seedlings which can probably be attributed to increased competition from the ground vegetation. Permanent quadrats set up soon after fencing and recorded in 1961 and 1966 confirm this increase which has probably been accelerated by the rather open canopy of the wood. A similar decline in the production of ash seedlings may also be occurring at Gorswen but in this case the competition is more with pre-existing seedlings than with the other ground vegetation which is almost absent from some areas of the wood anyway.

In the three other areas with ash seedlings (Dolgarrog 1 and 2 and Ganllwyd) the age distribution were limited to the first 4 years with a peak in the 2nd year which would seem to indicate that 1964 was a good ash seed year.

(e) Sycamore

Sycamore is considered to be a non-indigenous species in the woodlands of North Wales and a programme of elimination by means of girdling (and some fellings) was initiated at Gorswen in 1963. In the light of this information it is easy to understand the steady decline in sycamore seedlings since this time culminating in the complete absence of 1st year seedlings in 1966. The peak density in the 4th year is also seen in Dolgarrog 1 and the obvious conclusion is that 1962 was an exceptional seed year for sycamore (as it was for oak).

A more detailed discussion of the relationship of ash and sycamore seedlings at Gorswen appears later in this report.

(f) Holly

There is quite a wide age distribution of holly seedlings at Gorswen, as in most other places where the species occurs, suggesting that as a shade tolerant species it survives quite well under the prevailing light conditions. The method of seed dispersal by bird droppings enables holly seedlings to appear without fruiting holly trees in the immediate vicinity.

Height Growth of Seedlings

The height growth of oak seedlings as indicated in Figs. 7-11 is somewhat confused by the considerable scatter of height at any given age including 1st year seedlings. It therefore seems probable that the height of most of the seedlings observed was governed more by their performance in the 1st year of growth, and is thus to a large extent an expression of acorn size (Jarivs 1963), than by their subsequent growth. Only in Cymerau 2, is there any real indication of an increase of height with age and then only after about the 6th year.

In a number of cases 2nd year seedlings are smaller than those in their 1st year which could be due either to differences in acorn size and failure to put on further height increment after the 1st year or to actual loss in height after the 1st year, e.g. die-back. In Cymerau 1 there is a steady decline in height up to the 5th year! All the evidence suggests that, with the possible exception of a few seedlings in Cymerau 2, the oak seedlings observed in the survey are doomed to failure. The possible reasons for this failure will be discussed in more detail in a forthcoming paper on the results obtained from experimental planting of oak seedlings under a range of conditions.

The height growth of ash seedlings is shown in Fig. 12 and here there is some indication of an increase of height with age. This can probably be explained by the more open canopy in the wood, rather than by any features, such as shade tolerance, of the ash seedlings. Unfortunately, owing to the high density of seedlings, no systematic height data on ash was collected at Gorswen.

Only the very scant results for holly shown in Fig. 13 (unfortunately again no data are available for Gorswen) show any real indication of an increase of height with age, thus confirming the potential survival of this shade tolerant species.

The Relationship of Ground Cover Type to Regeneration

The results of the 10 cm diameter quadrat estimates of ground cover have only been worked out in detail for oak seedlings and the following is a summary of the percentage cover for five of the areas studied:

Site	Ground Cover Type %					
	Litter	Moss	Grass	Herbs	Wood	Bare Ground
Dolgarrog 1	67	8	14	6	5	-
Cymerau 1	74	24	12	*	-	-
Maentwrog	70	16	11	2	-	-
Camlyn	51	28	3	18	-	1
Rhygen	40	46	7	7	-	-

* Sample taken early in survey with grass and herbs mixed but herbs less than 4%

There is an obvious correlation here between a ground cover of litter, and in some cases moss, and the presence of oak seedlings. Unfortunately it is difficult to discuss this observation further in the absence of comparative data on the overall proportion of the various ground cover categories in the wood. This could have been obtained by the recording of a number of random 10 cm quadrats but was not in fact, carried out. However, the association between oak seedlings and litter or moss is borne out by other work (Shaw 1968a and b).

There was also a very clear association between birch seedlings and cushion mosses, particularly Leucobryum glaucum. The effect was most pronounced in the case of young seedlings and is obviously related to the provision of a suitable seed-bed for the germination of the small-seeded birch and the survival of the initially small seedling. Young birch were also associated with bare ground probably for the same reason. Rowan seedlings also seemed to show a definite preference for moss swards, particularly the more open type produced by the larger mosses such as Polytrichum spp., Thuidium tamariscum and Rhytidiadelphus loreus. Ash seedlings showed a definite association with the presence of exposed mineral soil.

Tree Cover - Type and Density

Little useful information was obtained from the recording of this data except that the larger and older seedlings usually occurred under less dense canopy conditions, as might be expected. Only the heavy-seeded oak seemed to be related to the canopy species in the immediate vicinity, again a fairly obvious conclusion.

Slope of the Ground

This data yielded no useful information in the present study.

Ash and Sycamore Seedlings at Coed Gorswen

The feasibility trial of the method carried out at Gorswen in 1964 enables a comparison to be made between the results obtained then and in the present study. Despite the fact that the two samples were not taken from exactly the same area of the wood the density of ash seedlings in 1964 is seen to be closely comparable with that in 1966; 68.6 and 73.2 seedlings/sq metre respectively. The equivalent results for sycamore of 16.4 and 9.7 seedlings/sq metre respectively are not quite so comparable and suggest a decline in density of this species.

The comparison of observed age distributions is shown in Fig. 14 (note the 2 year displacement). The age distribution of ash in 1966 is clearly an extension of that found in 1964 allowing for about a 50% mortality in the conversion of 1st into 3rd year seedlings. By contrast the age distribution for sycamore contains a number of anomalies, i.e. there are no 1st year seedlings in 1964 but there are 3rd year seedlings in 1966 and the high density of 3rd year seedlings in 1964 is incompatible with the low density of 5th year seedlings in 1966. From these observations it can only be assumed that particular populations of sycamore seedlings are more localised than those of ash and that difference in sampling area has resulted in certain anomalies.

With regard to interspecific competition between the two species it is interesting to note that not only has ash been the most prolific regenerator at Gorswen (not taking the number of seed-bearers into account) but seedlings of this species also seem to survive longer (up to at least 10 years) compared with sycamore (up to only 6 or 7 years).

Conclusion

Firm conclusions, other than those of a very general nature, would be unwarrented after the preliminary study just described. A fairly wide range of species were found to be regenerating on most of the sites investigated but the evidence from the age distributions and height growth was that most of the seedlings observed were unlikely to develop into adult trees. There were interesting indications with respect to the development of understorey species in several of the woods now that grazing has been largely eliminated.

More positive conclusions and suggestions for improvements on the methods to be employed in future investigations can however be made:

(1) The quadrat method of determining density and age distribution was quite satisfactory except for species with low densities where larger samples are required.

(2) The method of age determination by sectioning is also quite satisfactory except for young highly suppressed seedlings of ash and possibly oak.

(3) More comprehensive data on seedling height would give better age height curves which would be very useful in determining the probable survival and ultimate success of seedlings.

(4) More detailed information on the ground cover types in relation to the various seedling species would be useful. Future investigations should estimate the ground cover by individual species and also their height where possible. An estimate of the overall proportion of ground cover is also required.

(5) Repeated surveys of the type just described should yield a useful range of information on such things as seed years, seedling yield, seedling mortality, etc., as well as the changes that are occurring as a result of fencing.

Acknowledgements

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Shaw, M. W. (1968b). Factors affecting the natural regeneration of sessile oak (Quercus petraea) in North Wales. II. Acorn losses and germination under field conditions. J. Ecol., 56, 647-60.

Table 1. SUMMARY OF SEEDLING DENSITIES

Site	No. of ½ sq. m. quadrats	SEEDLING SPECIES - DENSITY (Numbers/sq. metre)											Total Seedling Density
		Oak	Birch	Rowan	Ash	Sycamore	Holly	Beech	Cherry	Hazel	Hawthorn	Blackthorn	
Coed Gorswen	25	0.24	-	0.48	73.20	9.68	3.92	-	0.08	0.16	-	-	87.76
Cwm Glas Crafnant	78	-	0.16	0.11	2.68	-	-	-	-	-	0.05	0.03	3.03
Coed Dolgarrog 1	100	0.98	1.78	0.10	0.12	0.64	0.52	0.14	-	0.02	-	-	4.30
Coed Dolgarrog 2	100	-	0.10	0.10	0.70	-	0.06	-	-	-	0.06	0.42	1.44
Coed Cymerau 1	100	0.84	0.36	0.18	-	0.02	-	-	-	-	-	-	1.40
Coed Cymerau 2	100	0.56	1.00	0.06	-	-	-	-	-	-	-	-	1.62
Coed Maentwrog	100	0.22	0.04	1.26	0.06	0.10	-	-	-	-	-	-	1.68
Coed Camlyn	100	0.26	0.78	0.16	-	-	0.04	-	-	-	-	-	1.24
Coed-y-Rhygen	100	0.26	0.14	0.28	-	-	-	-	-	-	-	-	0.68
Coed Ganllwyd	100	0.02	0.16	0.04	0.22	0.02	-	-	-	-	-	-	0.46

Figure 1.

OAK.

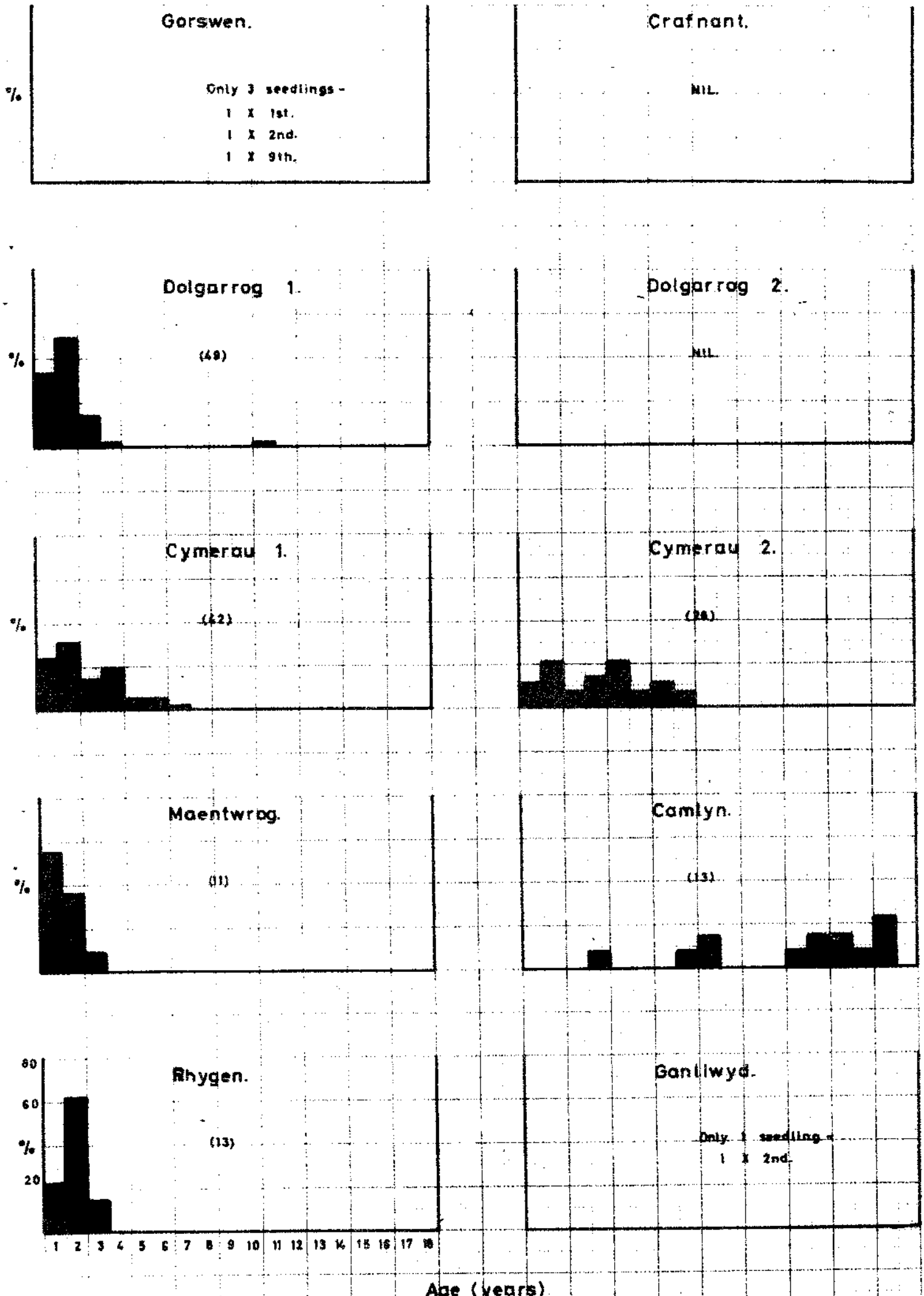
Gorswen.
%
Only 3 seedlings -
1 X 1st.
1 X 2nd.
1 X 9th.
Crafnant.
NIL.
Dolgarrog 1.
%
(49)
Dolgarrog 2.
NIL.
Cymerau 1.
%
(42)
Cymerau 2.
(28)
Maentwrog.
%
(11)
Camlyn.
(13)
Rhygen.
%
(13)
Ganllwyd.
Only 1 seedling -
1 X 2nd.
Age (years)

Figure 2.

BIRCH.

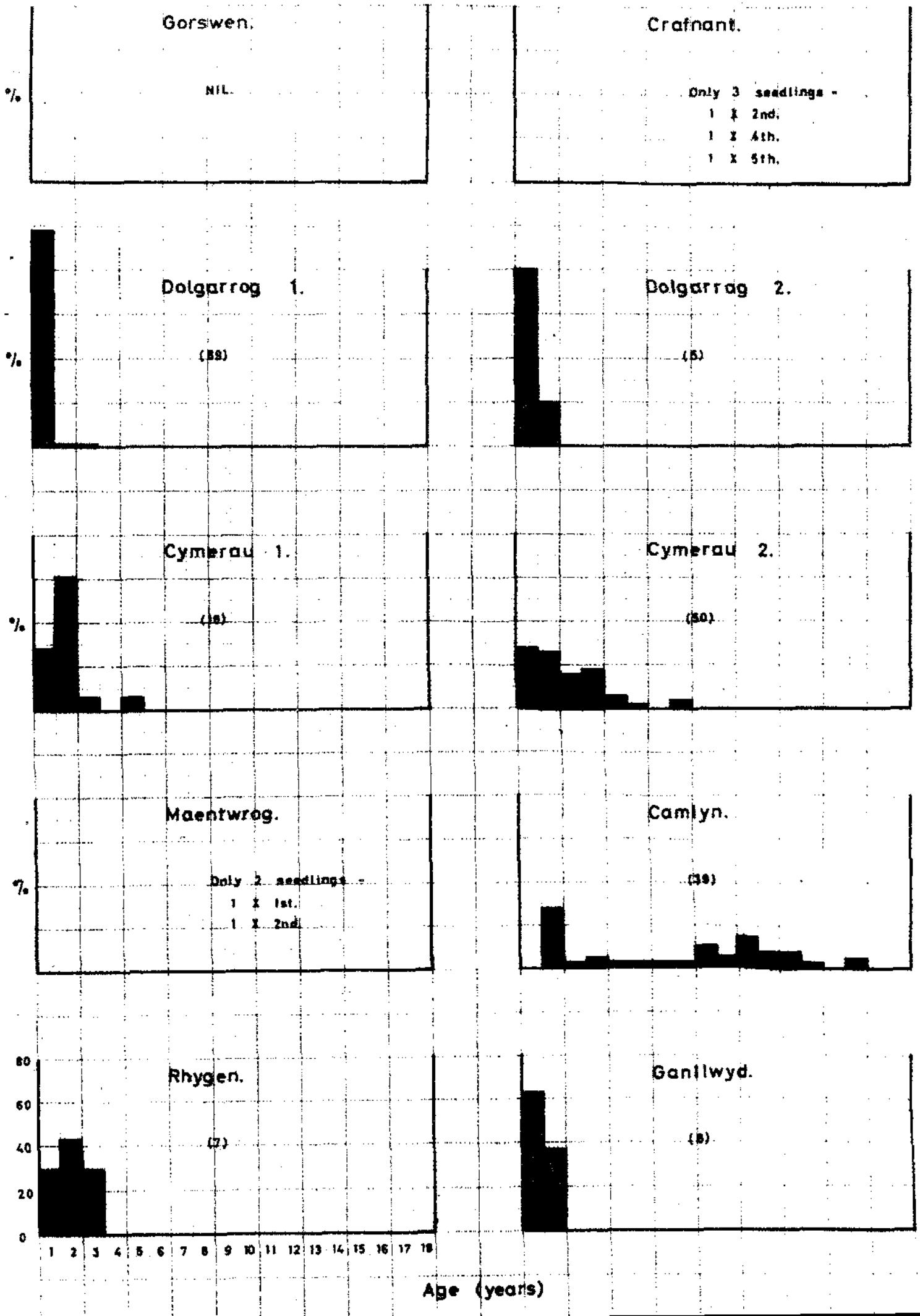

Figure 3.

ROWAN.

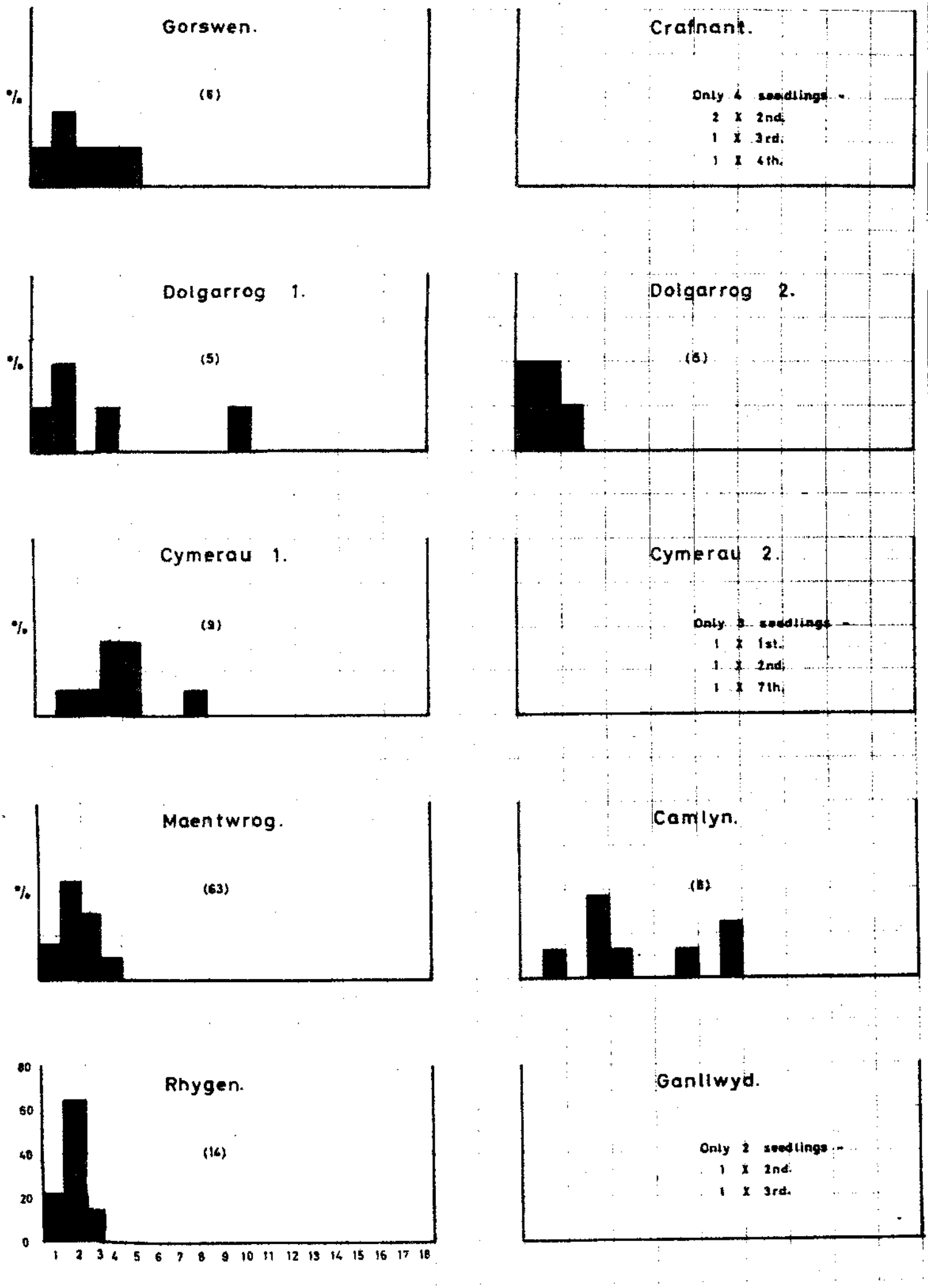

Figure 4.

ASH.

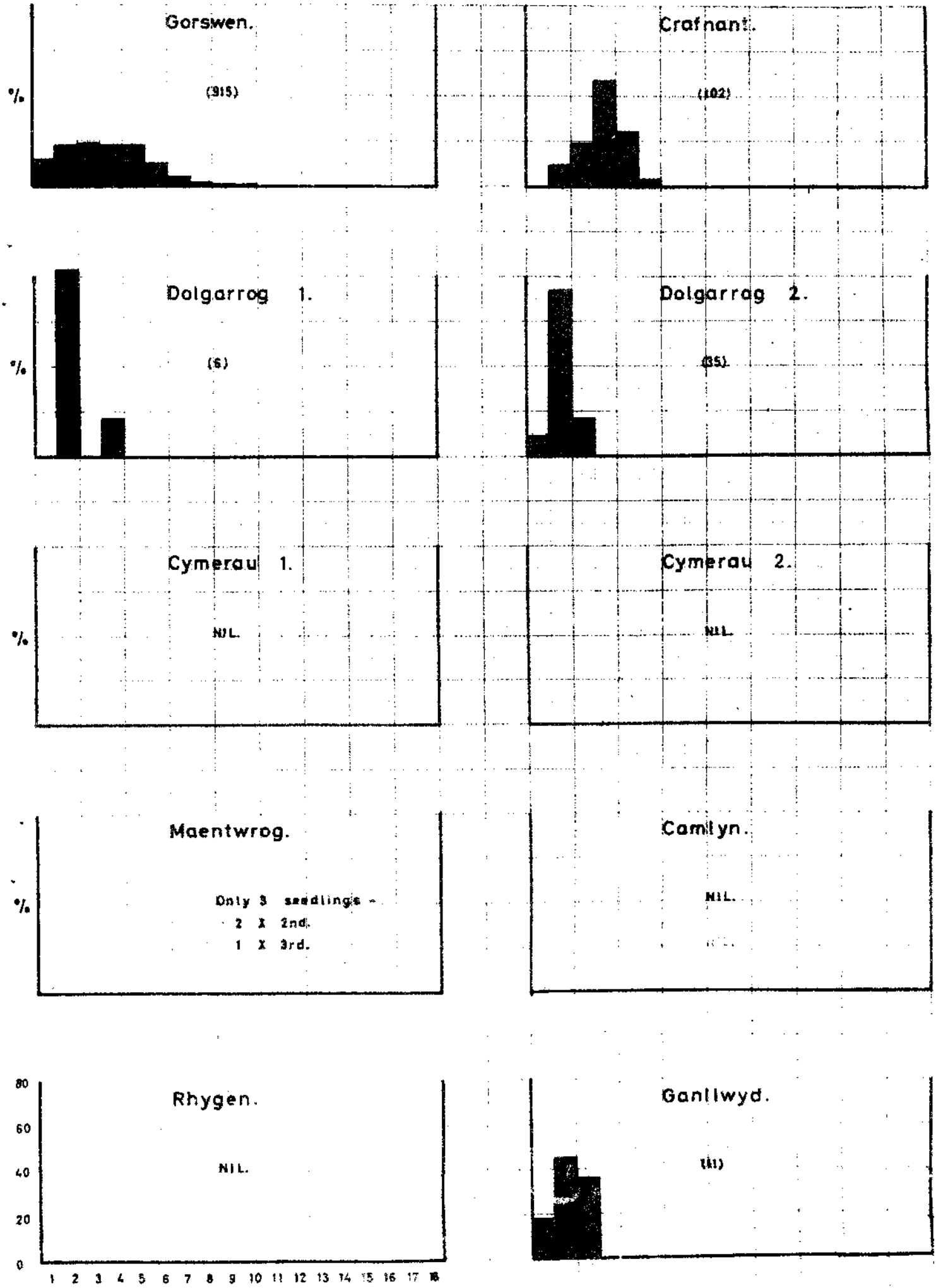
Gorswen.
(915)
%
Crafnant.
(102)
Dolgarrog 1.
(6)
%
Dolgarrog 2.
(35)
Cymerau 1.
NIL.
%
Cymerau 2.
NIL.
Maentwrog.
%
Only 3 seedlings -
2 X 2nd.
1 X 3rd.
Camlyn.
NIL.
Rhygen.
NIL.
Ganllwyd.
(11)
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Age (years)

Figure 5.

SYCAMORE.

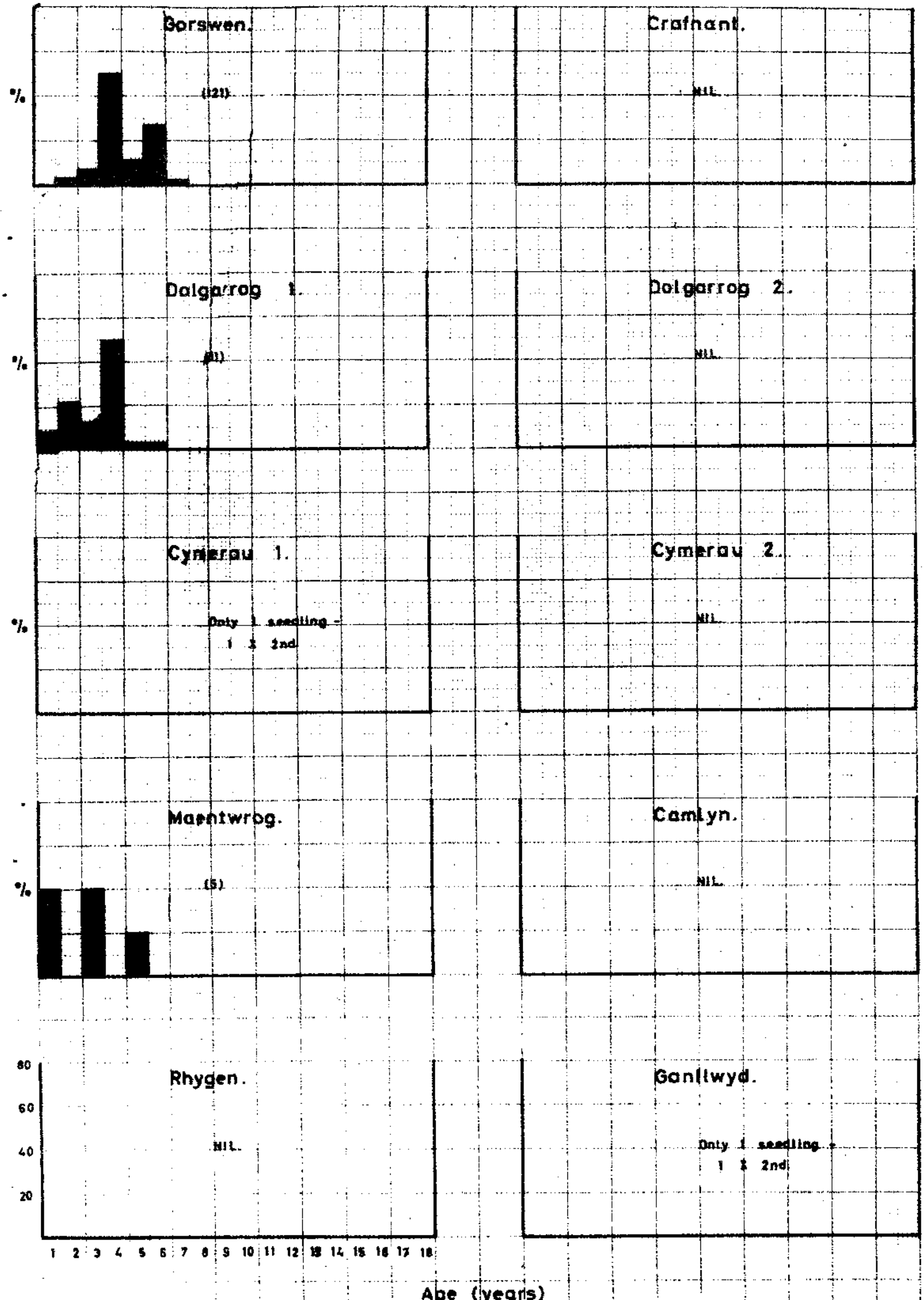

Figure 6.

HOLLY

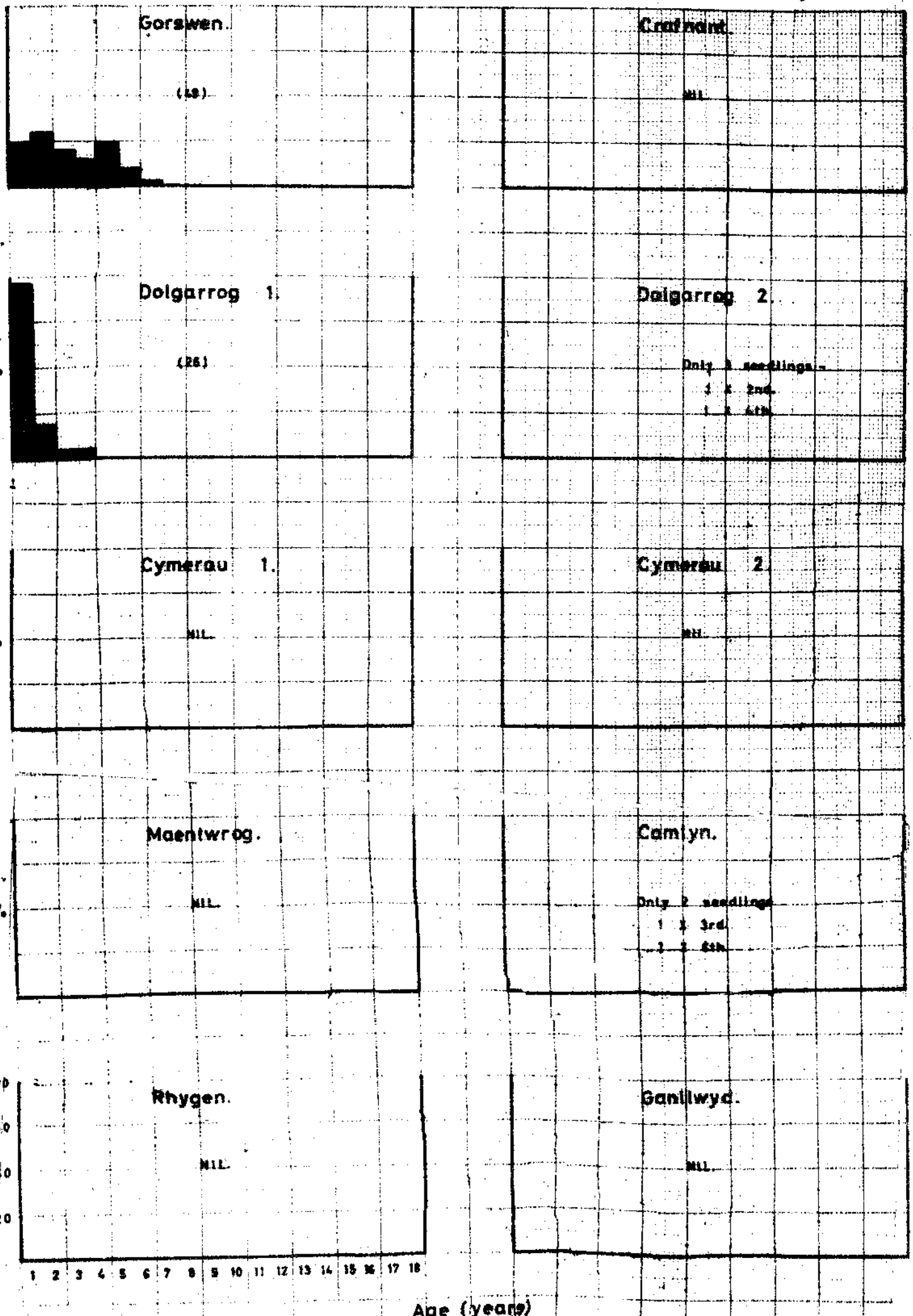

Figure 7.

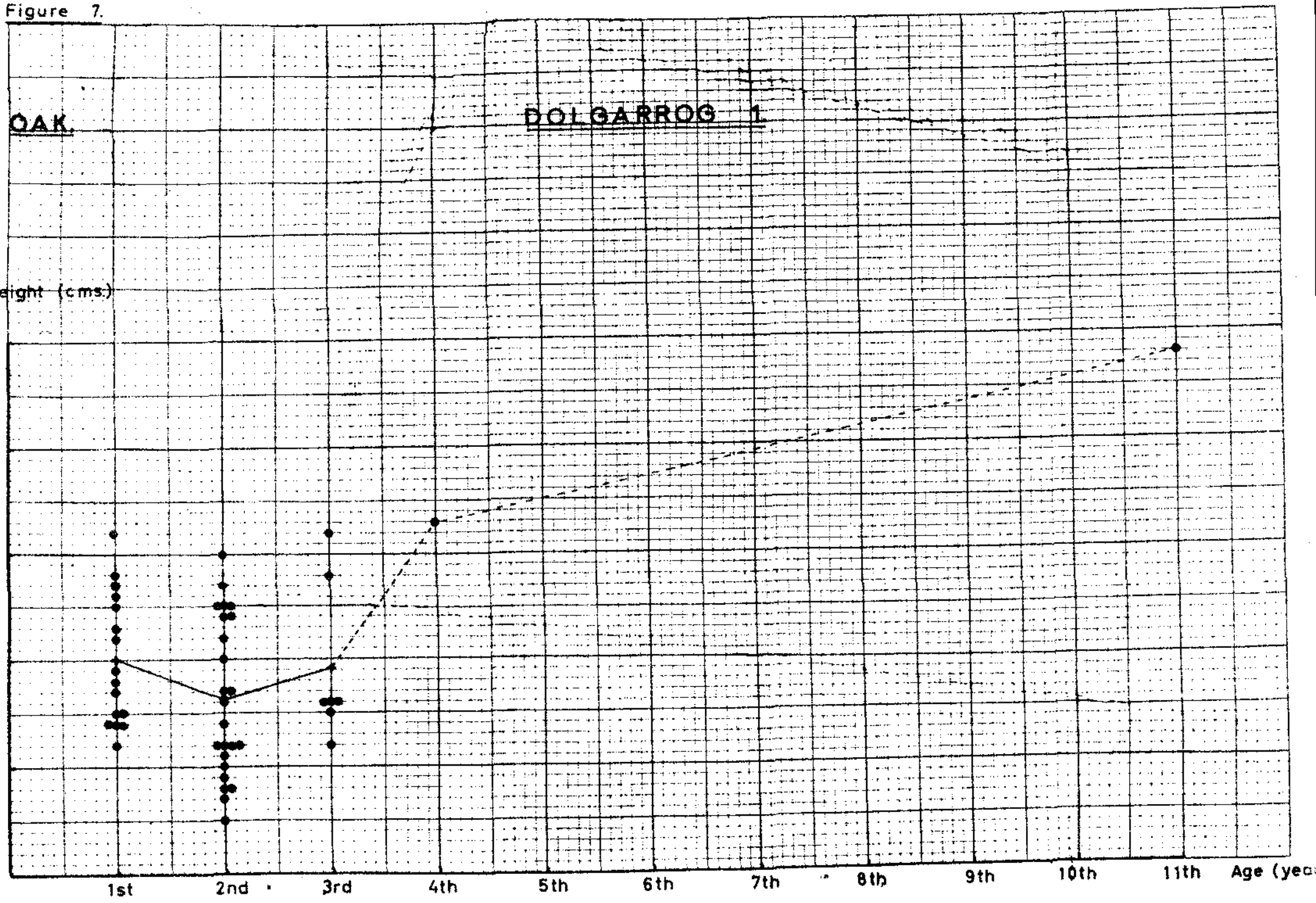
OAK.
DOLGARROG 1.
Weight (cms.)
25
20
15
10
5
0
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
11th
Age (yea

Figure 8.

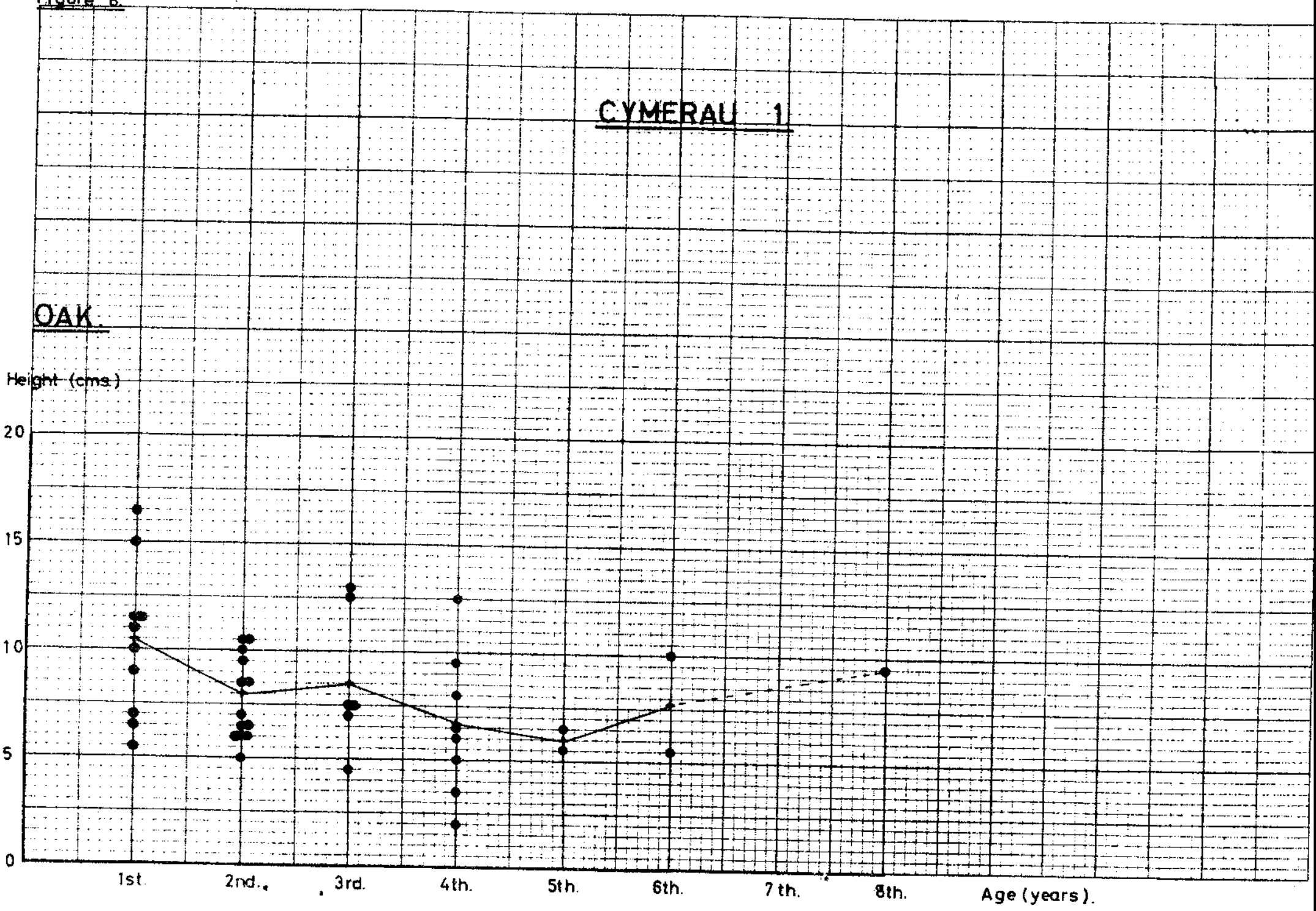
CYMERAU 1
OAK.
Height (cms.)
20
15
10
5
0
1st
2nd.
3rd.
4th.
5th.
6th.
7th.
8th.
Age (years).

Figure 9.

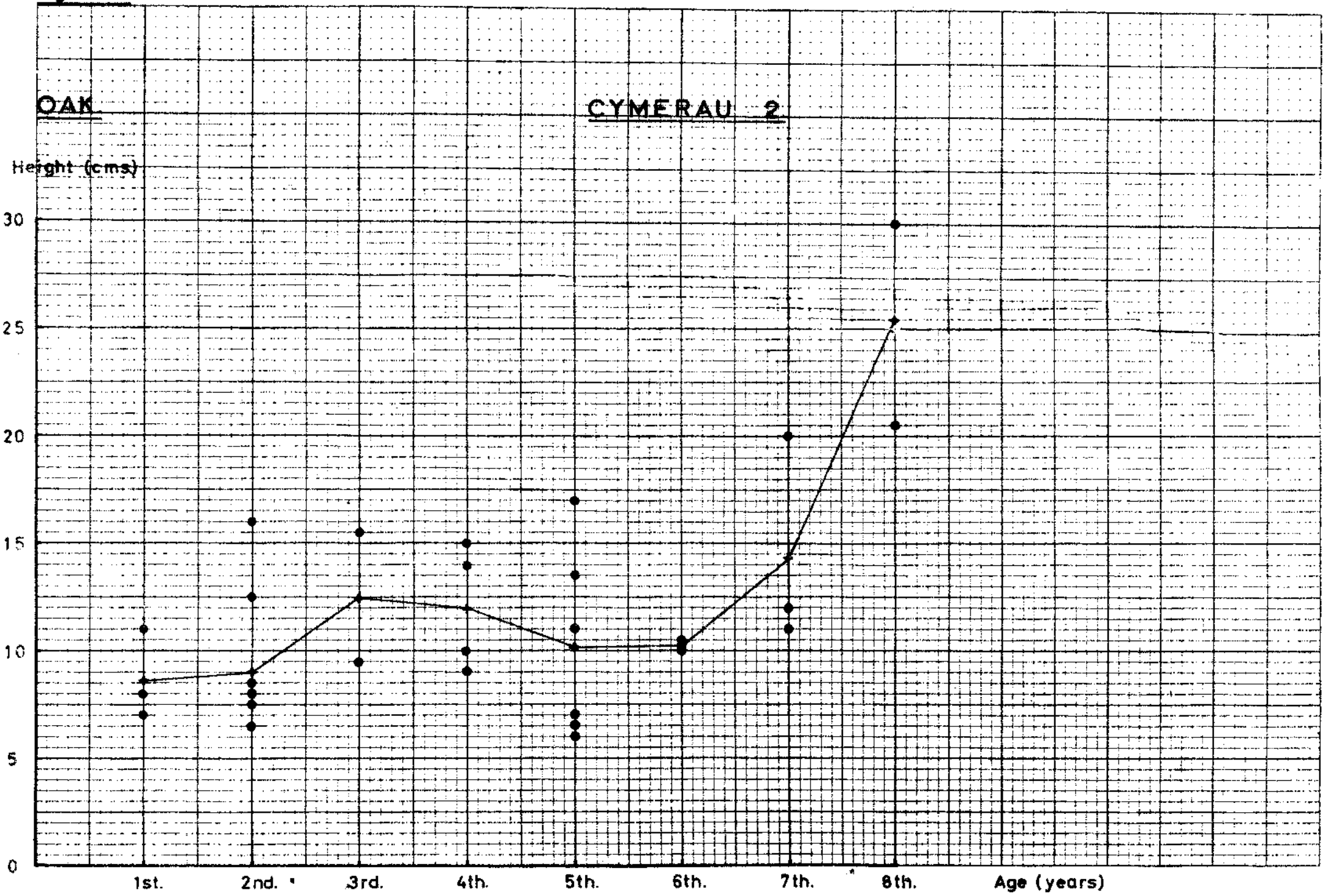
OAK
CYMERAU 2
Height (cms)
30
25
20
15
10
5
0
1st.
2nd.
3rd.
4th.
5th.
6th.
7th.
8th.
Age (years)

Figure 10.

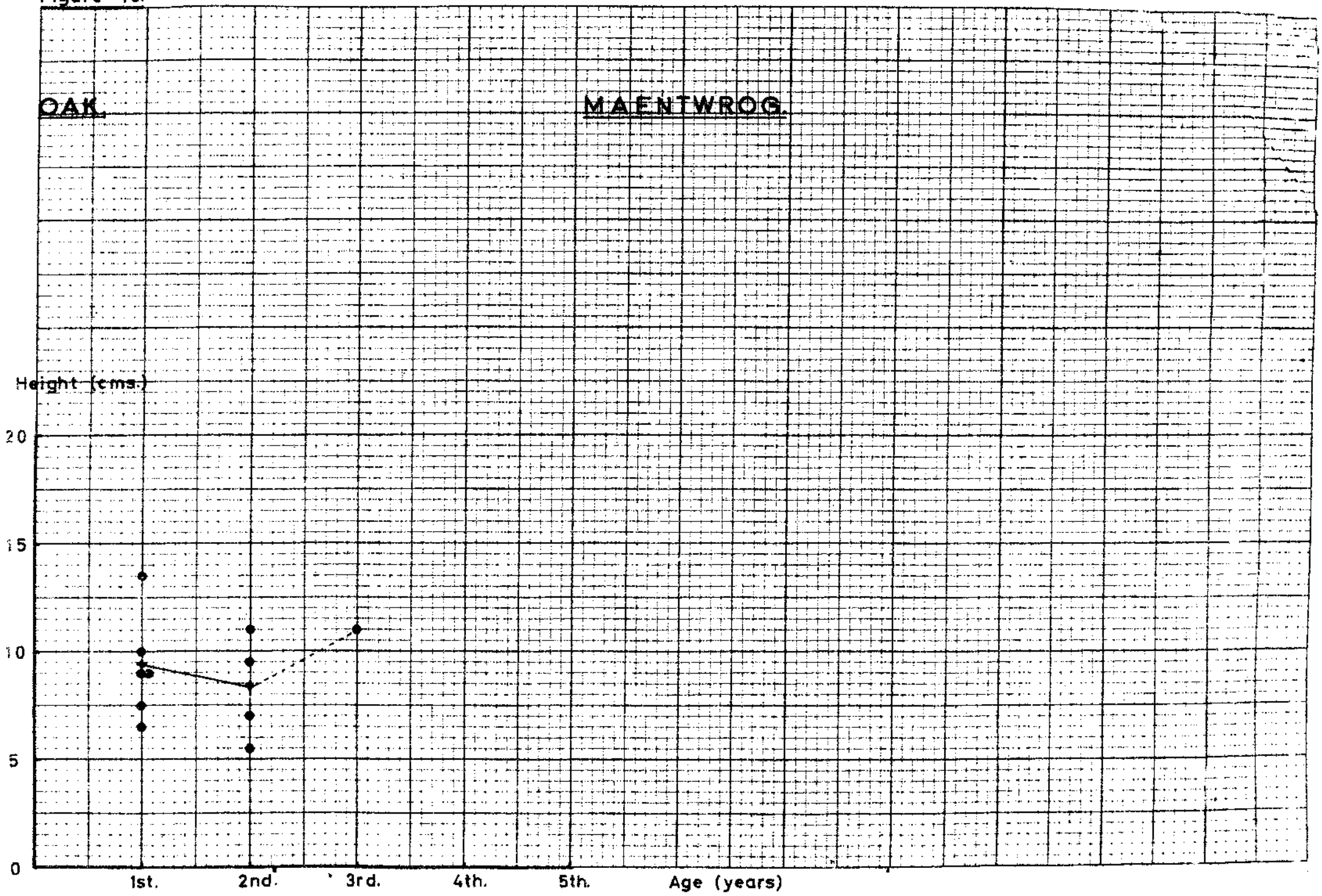
OAK.
MAENTWROG.
Height (cms.)
20
15
10
5
0
1st.
2nd.
3rd.
4th.
5th.
Age (years)

Figure 11.

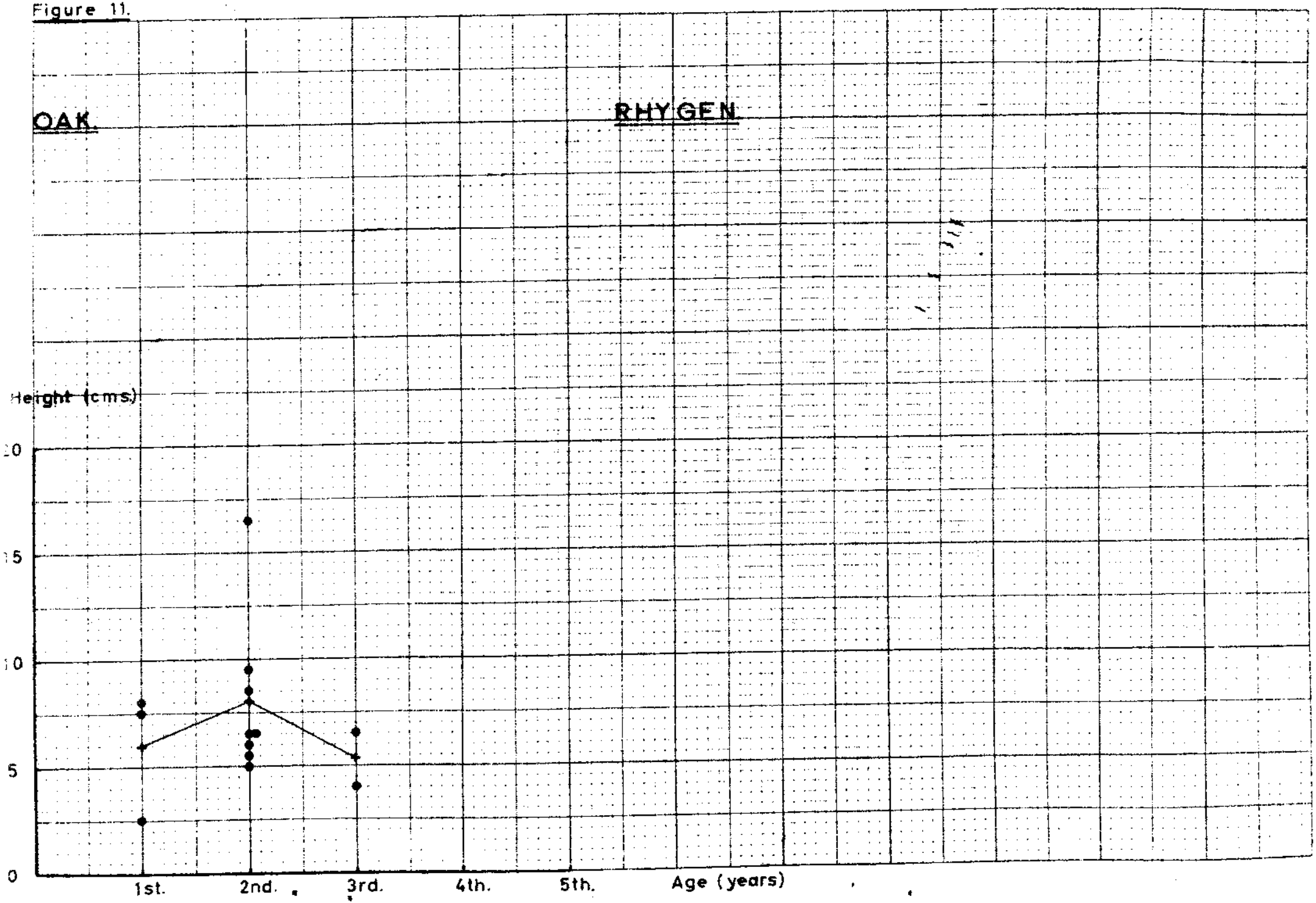

Figure 12.

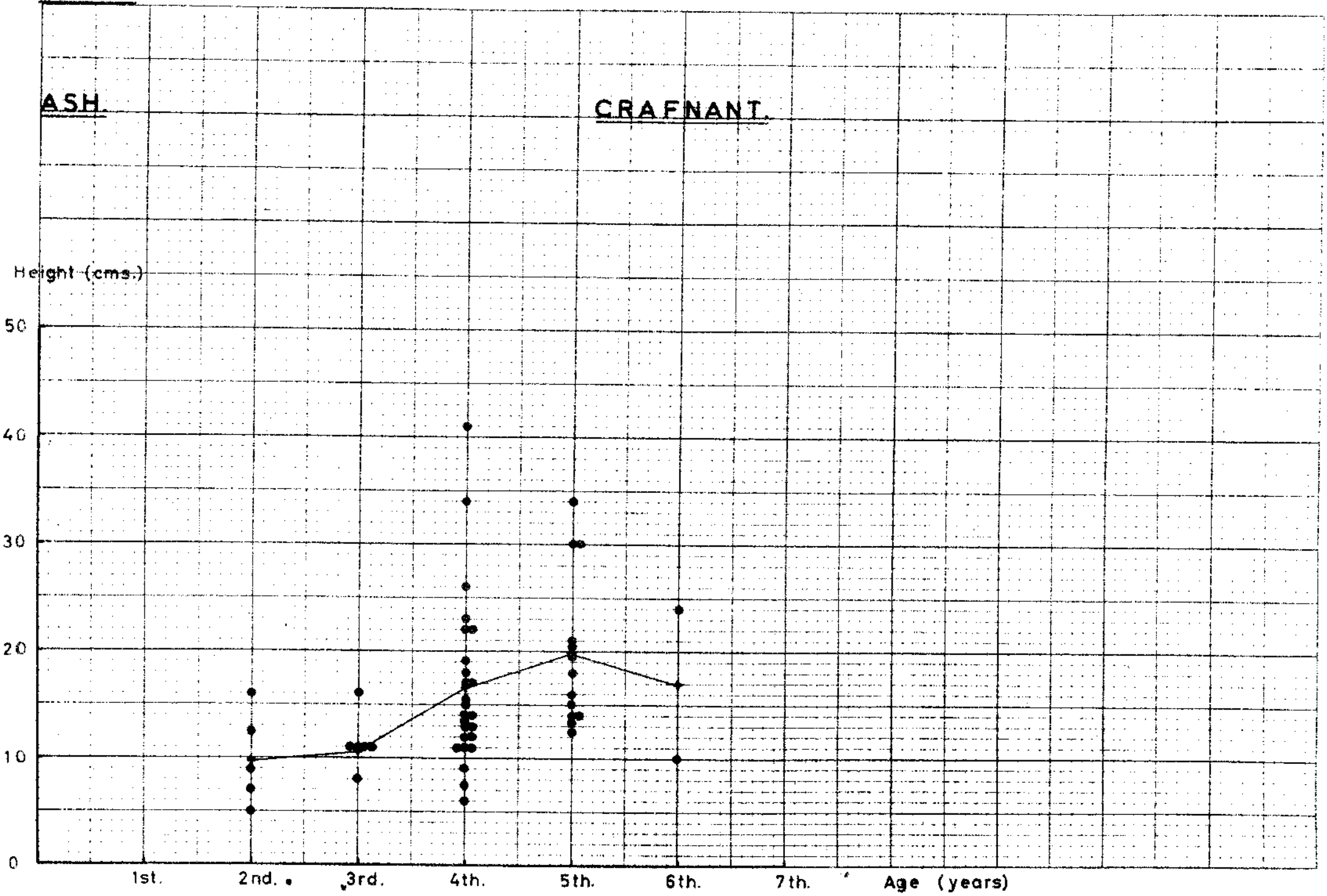
ASH
CRAFNANT.
Height (cms.)
50
40
30
20
10
0
1st.
2nd.
3rd.
4th.
5th.
6th.
7th.
Age (years)

Figure 13.

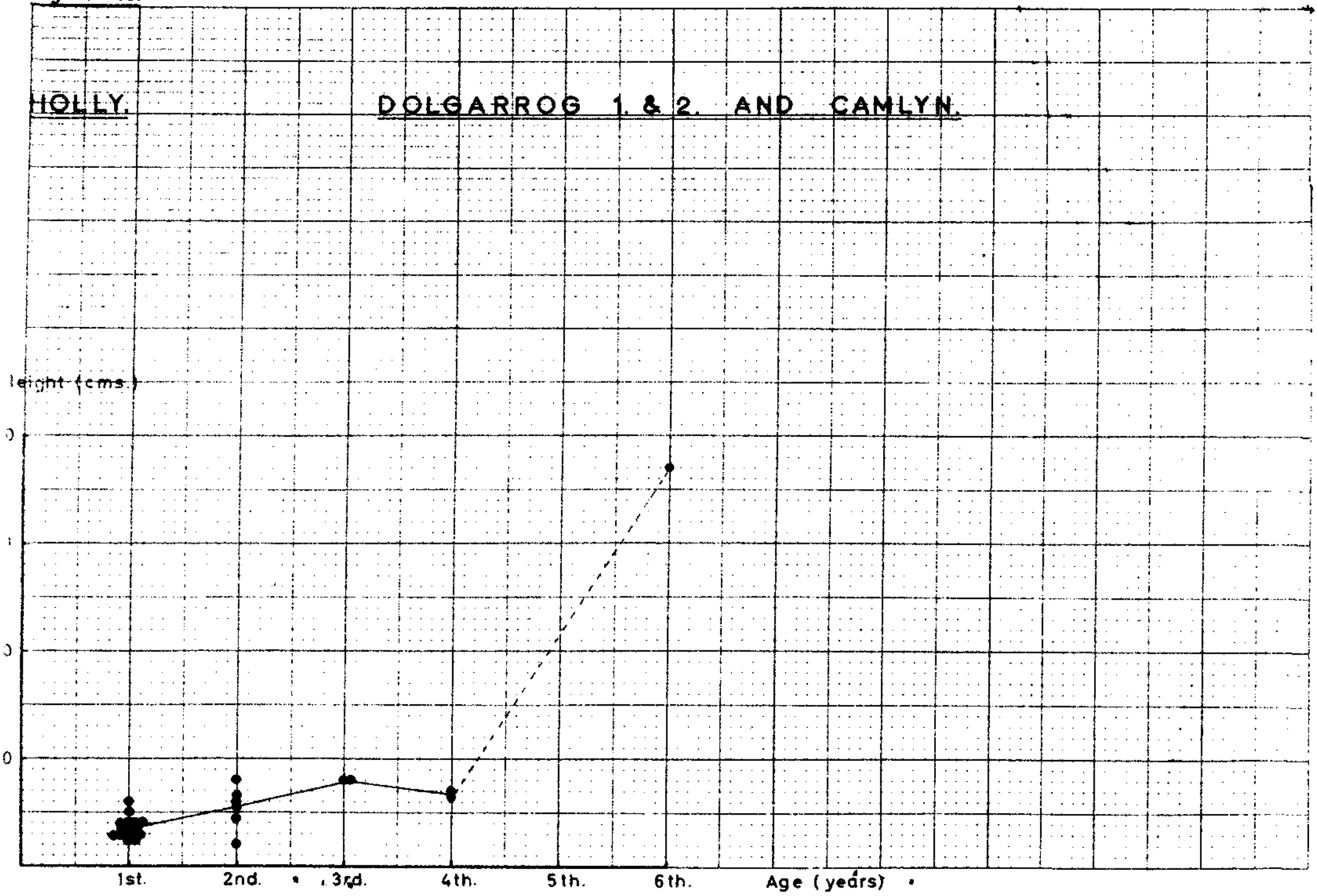
HOLLY.
DOLGARROG 1. & 2. AND CAMLYN.
eight (cms.)
0
0
1st.
2nd.
3rd.
4th.
5th.
6th.
Age (years)

Figure 14. COMPARISON OF AGE DISTRIBUTIONS - ASH AND SYCAMORE - GORSWEN.