

EVAPORATION MEMO No 19

by B.G. Wales-Smith

An attempt to estimate the reliability of records of monthly totals
of daily measurements of evapotranspiration obtained from a network
of irrigated, non-weighing lysimeters.

Introduction

This work is an extension and application of that reported in Evaporation Memo No 18 and should be read in conjunction with the earlier memo.

Estimates

Some of the Penman estimates used in this investigation were calculated by computer and some were calculated by hand (using a desk calculator). The same constants were used for all calculations. In a few cases the station instrumentation did not provide all the data required and estimates of missing data (usually average daily duration of bright sunshine) were obtained from other stations judged to be representative.

Measurements

All measurements were made with irrigated, non-weighing lysimeters.

Period

Data and estimates are for all or part of the decade 1961-1970

Stations

Fig.A shows the stations used in the investigation and Fig.B. shows climatological stations, other than the lysimeter stations, used for Penman estimates of potential evapotranspiration.

On Fig.A inter-station lysimeter comparisons are indicated by full lines. The dashed lines show the inter-station comparisons made in Memo 18. The ringed numbers refer to the numbered Figures (1-29) and also to the listed comparisons.

Inter-station relationships of (Penman) potential Evapotranspiration.

Figures 3 to 6 of Memo 18 and Figures C to J of this memo show the expected, excellent, inter-station correlation of PE, and decreasing PE with increasing altitude. They also confirm the reliability of the calculations, especially those done by hand.

Analysis

52 scatter diagrams were plotted, comparing lysimeters with one another and with PE estimates from the same stations or from stations in the same general area.

The main value of the inter-station lysimeter comparisons is to demonstrate, as already shown for some stations in Table I of Memo 18, that in some cases inter-station correlation is as good, or almost as good, as that obtained with Penman estimates. On physical considerations it is reasonable to expect that daily measurements totalled over a period as long as a calendar month from any pair of like lysimeters, carefully managed and in the same part of the country should (as monthly totals) be well correlated. Where monthly totals from a pair of lysimeters are well correlated over several years it must be the case that both records are reliable but where the correlation is poor there is, of course, doubt as to whether both or only one record should be regarded as being suspect.

In Table I the comparisons are listed and referred to the Figures by index numbers. A simple system of assessing correlation was adopted. A transparent overlay having two straight lines one inch apart was placed over each scatter diagram so as to include (between the lines) as many points as possible. The number of points falling outside the band was counted and expressed, with the total of points, for each comparison as a fraction (e/T) and as percentage ($100 e/T$).

It will be noticed that $100 e/T$ varies from 0 to 50 ; the distribution is summarized below

TABLE II

Numbers of cases of $100 e/T$ within given ranges.

0	1-10	11-20	21-30	31-40	41-50
(i) Inter-station lysimeter comparisons					
3	3	5	5		1
(ii) lysimeter-Penman comparisons					
5	13	12	3	1	1

The large proportion of the 52 comparisons with relatively low values of $100 e/T$ strongly supports the use of the methods described in this memo for estimating the reliability of irrigated lysimeter records.

The $100 e/T$ values for the "(P)-comparisons" of Table I are proposed as "station reliability indices", reliability being inversely proportional to the index.

February 1972

Meteorological Office
Met O 8c
Bracknell.

TABLE I.

Inter-station lysimeter comparisons and comparisons of lysimeters with Penman estimates of PE. T = No. of pairs. e = No. of points outside 1 inch band.

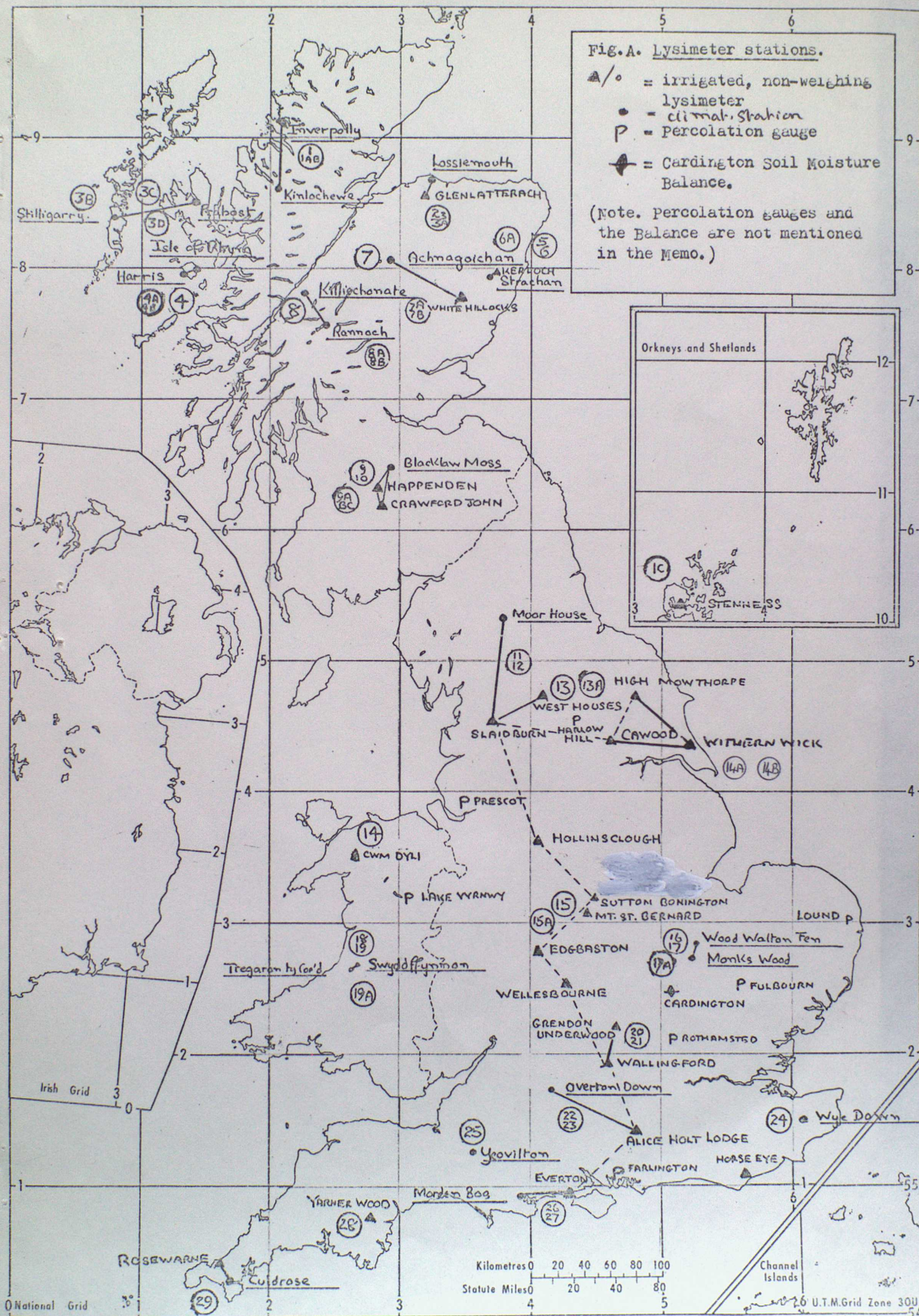
(Figure)	Stations.	(P) = Penman PE estimate.	e/T	e as % of T
(01)	Kinlochewe	Inverpolly	9/69	13
(01A)	Inverpolly	(P) Cape Wrath	8/87	9
(01B)	Kinlochewe	(P) Cape Wrath	7/72	10
(01C)	Stenness	(P) Grimsetter	5/43	12
(02)	Lossiemouth	Glenlatterach	14/100	14
(03)	Lossiemouth	(P) Kinloss	17/81	21
(03A)	Glenlatterach	(P) Kinloss	9/79	11
(03B)	Stilligarry	(P) Benbecula	10/36	28
(03C)	Stilligarry	Prabost	13/60	22
(03D)	Prabost	(P) Benbecula	8/90	9
(04)	Harris	Isle of Rhum	8/41	19
(04A)	Harris	(P) Benbecula	7/73	10
(04B)	Isle of Rhum	(P) Benbecula	4/42	9
(05)	Strachan (Moss-side)	Strachan (Kerloch)	10/39	26
(06)	Strachan (Moss-side)	(P) Dyce	9/70	13
(06A)	Strachan (Kerloch)	(P) Dyce	15/68	22
(07)	Achnagoichan	Whitehillocks	21/77	27
(07A)	Achnagoichan	(P) Dyce	19/120	16
(07B)	Whitehillocks	(P) Dyce	1/77	1
(08)	Killiechornate	Rannoch	10/33	30
(08A)	Rannoch	(P) Sloy	11/28	39
(08B)	Killiechornate	(P) Sloy	10/50	20
(09)	Happendon Crawfordjohn	Blacklaw Moss	0/17	0
(09A)	Happendon	(P) Eskdalemuir	0/32	0
(09B)	Crawfordjohn	(P) Eskdalemuir	0/45	0
(09C)	Blacklaw Moss	(P) Eskdalemuir	9/60	15
(10)	Blacklaw Moss	(P) Lowther Hill	6/57	11
(11)	Moor House	Slaidburn 21D	16/92	17
(12)	Moor House	(P) Great Dun Fell	9/47	19
(13)	West Houses	Slaidburn	2/20	10
(13A)	West Houses	(P) Slaidburn	2/20	10
(14)	Cwm Dyli	(P) Valley	12/112	11

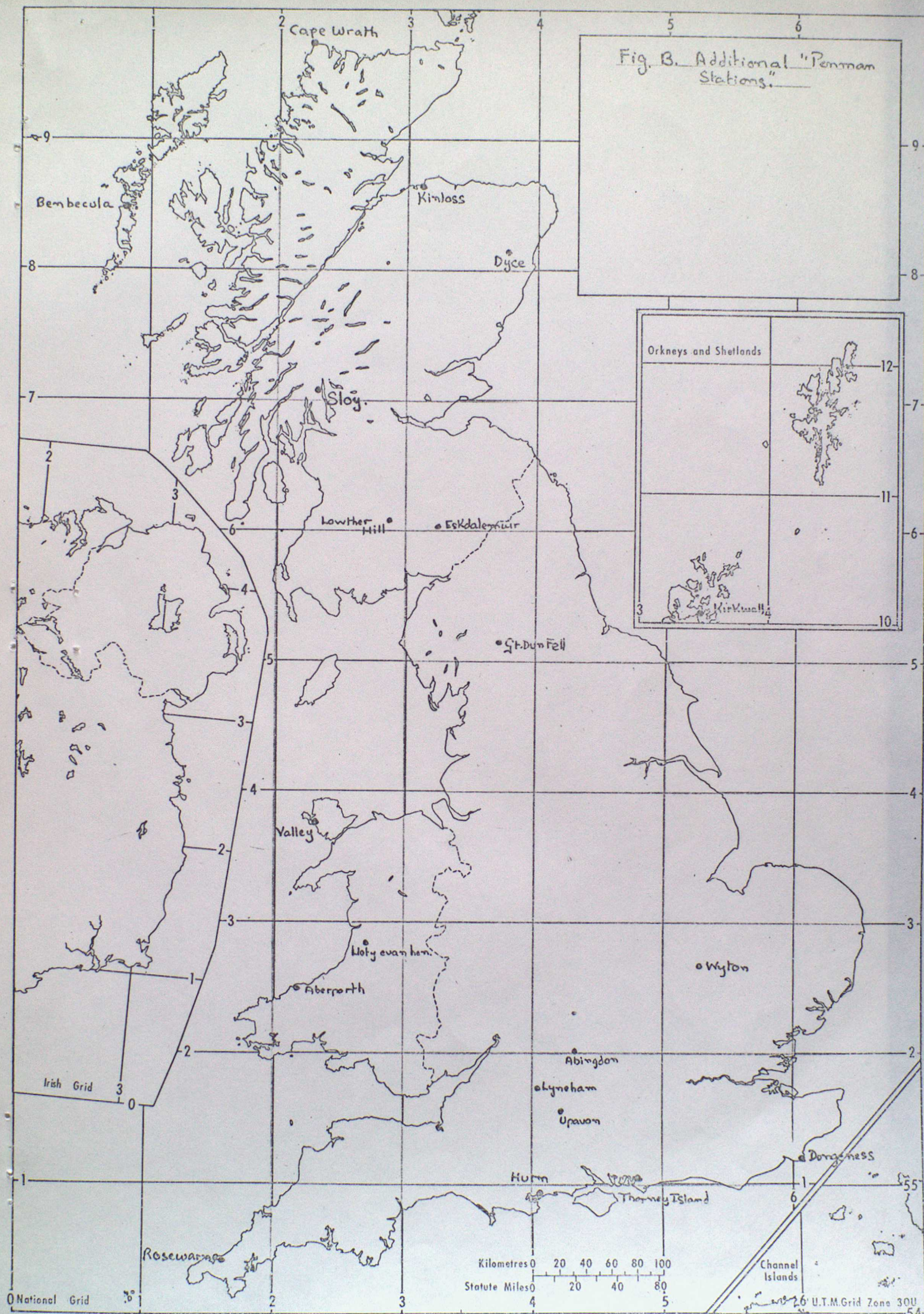
(14A)	Withernwick	High Mawtherpe	2/24	8
(14B)	Withernwick	Cawood	3/54	5
(15)	Mount St. Bernard	Sutton Bonington	4/66	6
(15A)	Mount St. Bernard	(P) Sutton Bonington	2/66	3
(16)	Monks Wood	Wood Walton Fen	8/51	16
(17)	Monks Wood	(P) Wyton	10/79	13
(17A)	Wood Walton Fen	(P) Wyton	2/40	5
(18)	Swyddffynnon	Tregaron Ty Coe'd	0/23	0
(19)	Swyddffynnon	(P) Llety evan hen	1/24	4
(19A)	Tregaron Ty Coe'd	(P) Llety evan hen	0/32	0
(20)	Grendon Underwood	Wallingford	5/21	24
(21)	Grendon Underwood	(P) Abingdon	2/27	7
(22)	Overton Down	Alice Holt Lodge	42/101	42
(23)	Overton Down	(P) Upavon	47/94	50
(24)	Wye Down	(P) Wye Down	3/45	7
		(P) Dungeness		
(25)	Yeovilton	(P) Yeovilton	0/12	0
(26)	Morden Bog	Everton	0/22	0
(27)	Morden Bog	(P) Hurn	9/58	15
(28)	Yarner Wood	(P) Yarner Wood	0/19	0
(29)	Culdrose	(P) Rosewarne	2/12	17

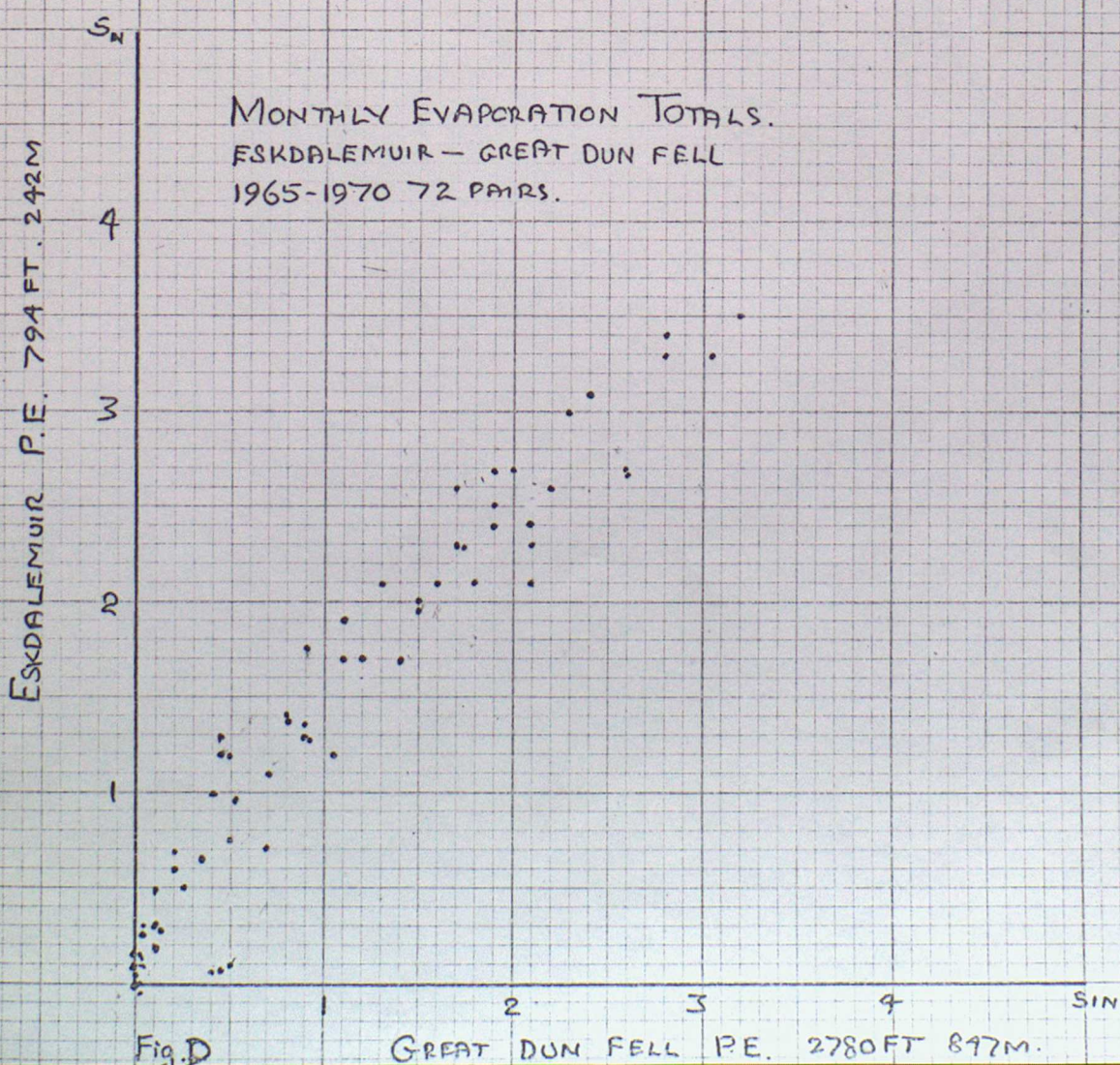
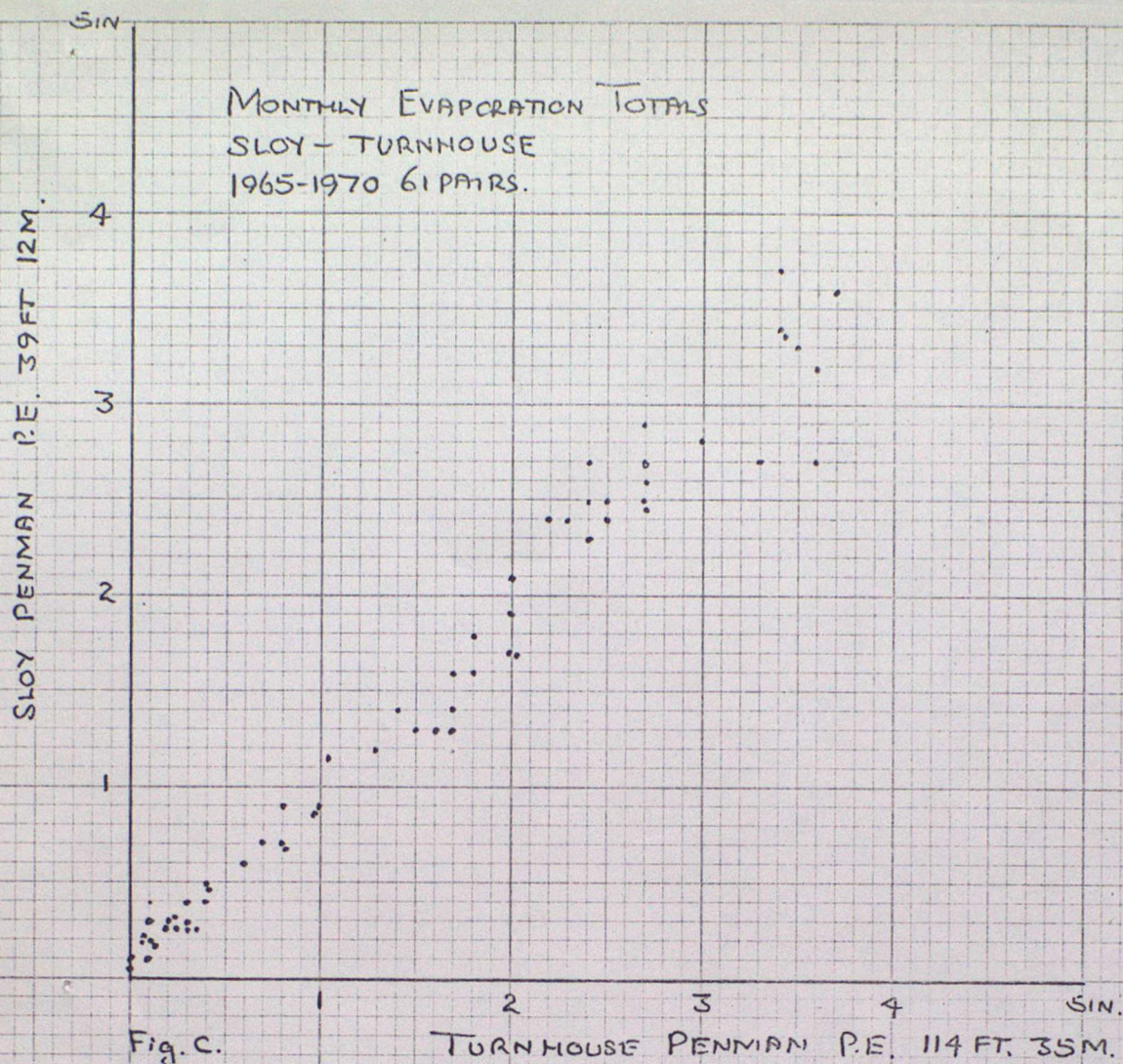
Fig. A. lysimeter stations.

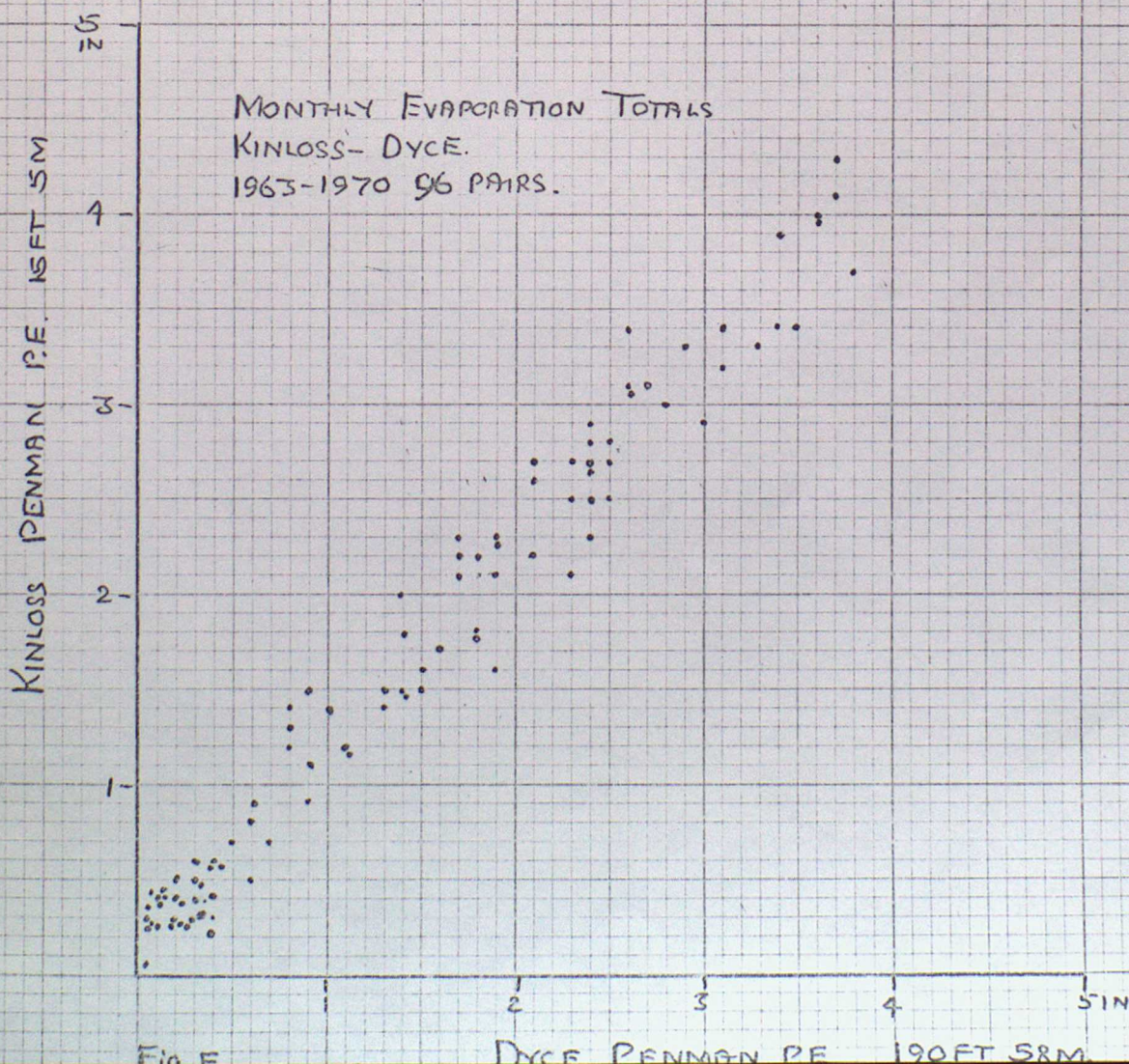
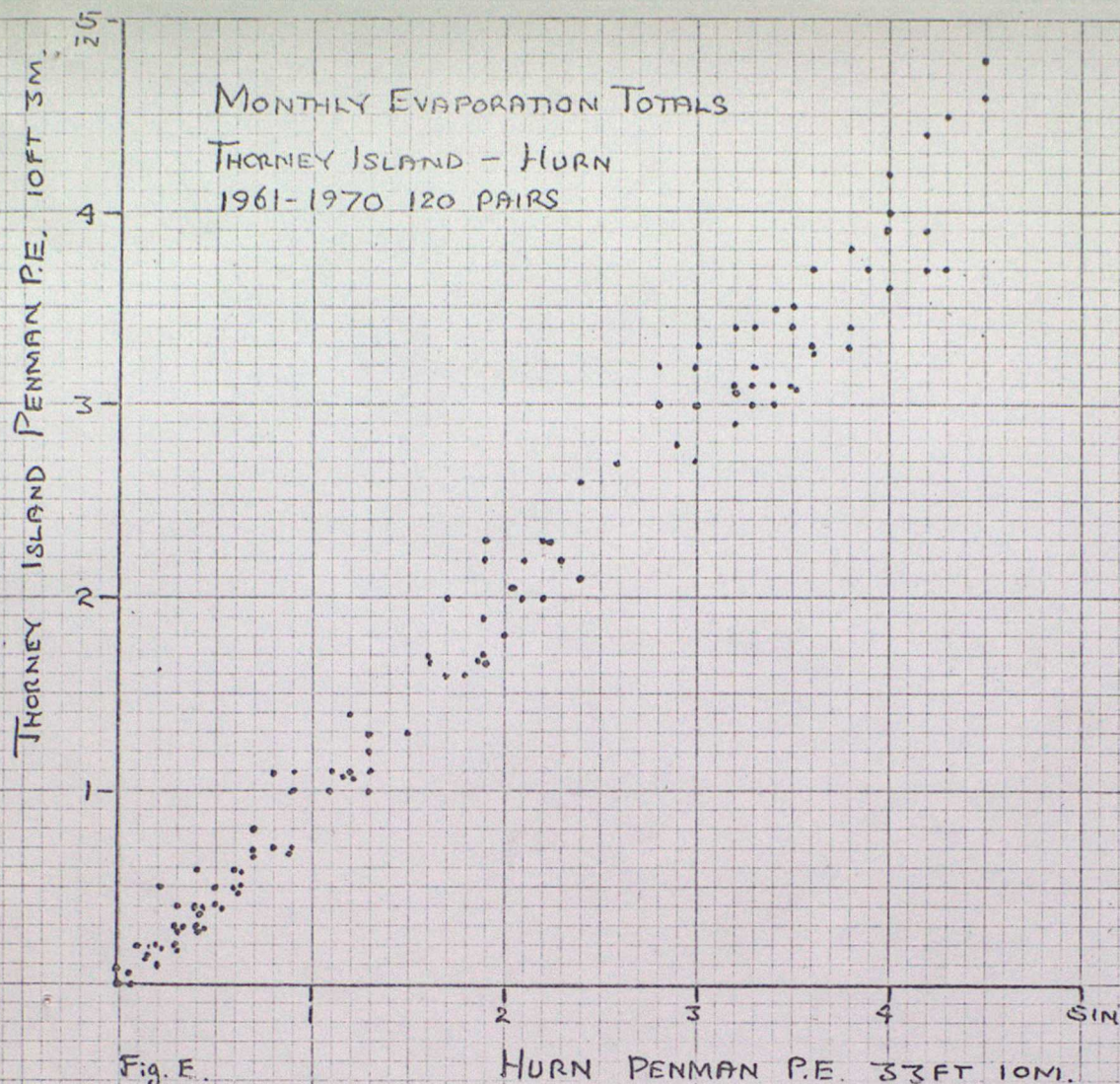
- ▲/○ = irrigated, non-weighing lysimeter
- = climat. station
- P = Percolation gauge
- ⊕ = Cardington Soil Moisture Balance.

(Note. percolation gauges and the Balance are not mentioned in the Memo.)









ESKDALEMUIR PENMAN P.E. 794 FT 242M.

MONTHLY EVAPORATION TOTALS
ESKDALEMUIR - LOWTHER HILL
1963-1968 60 PAIRS

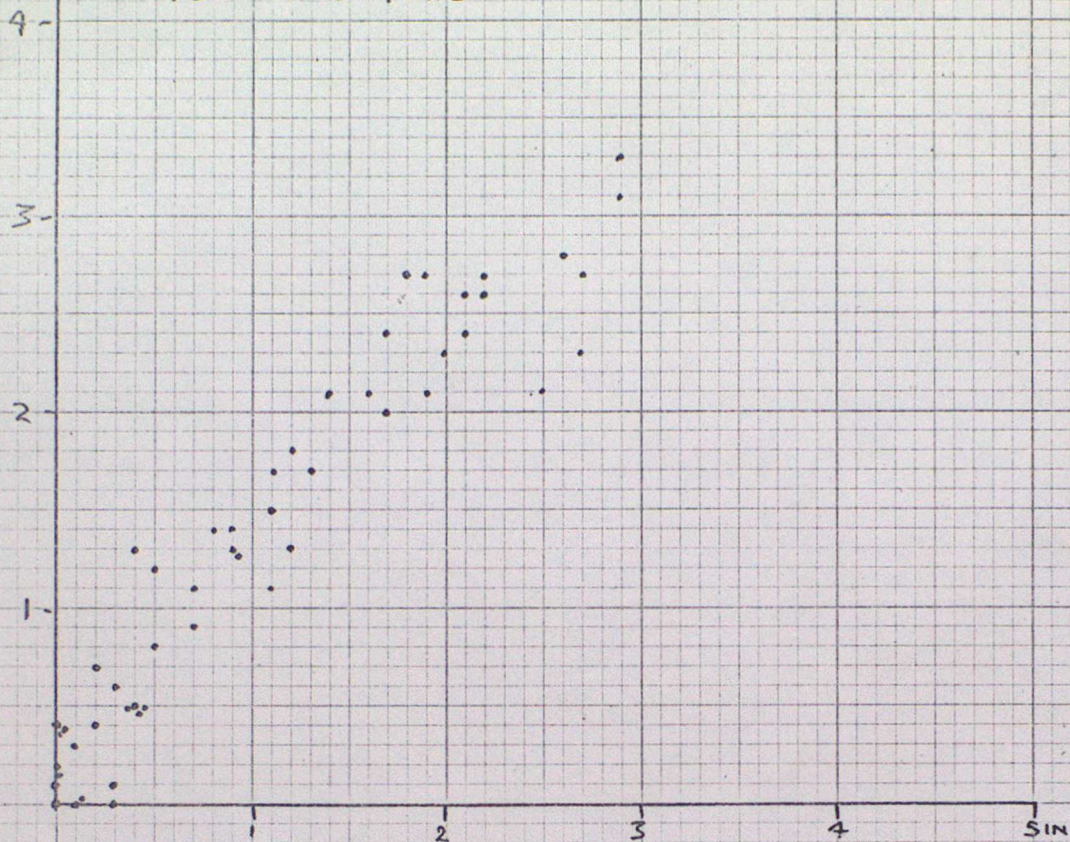


Fig. G.

LOWTHER HILL PENMAN P.E. 2372 FT 723M.

LYNEHAM PENMAN P.E. 455 FT 139 M.

MONTHLY EVAPORATION TOTALS
LYNEHAM - UPAVON
1963-1970 96 PAIRS

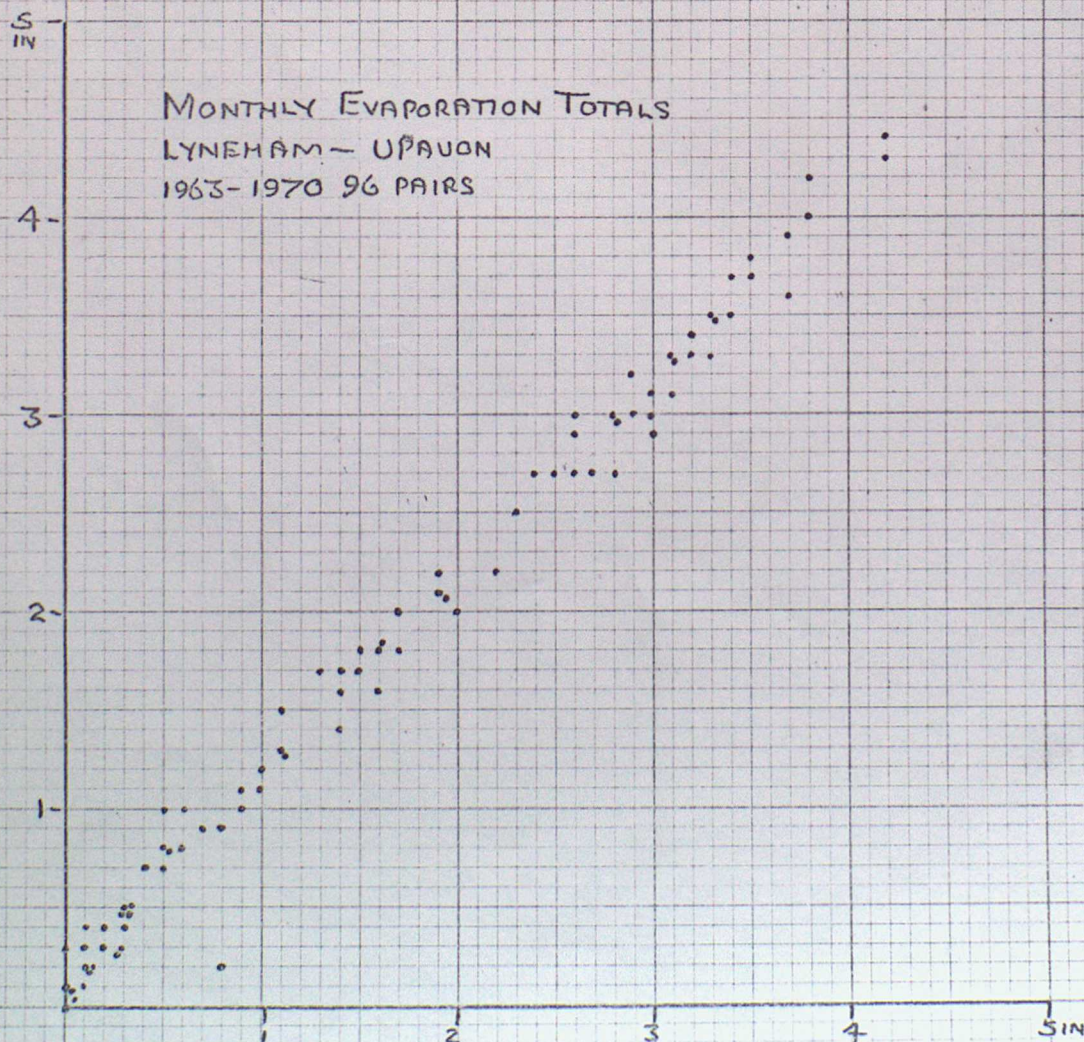
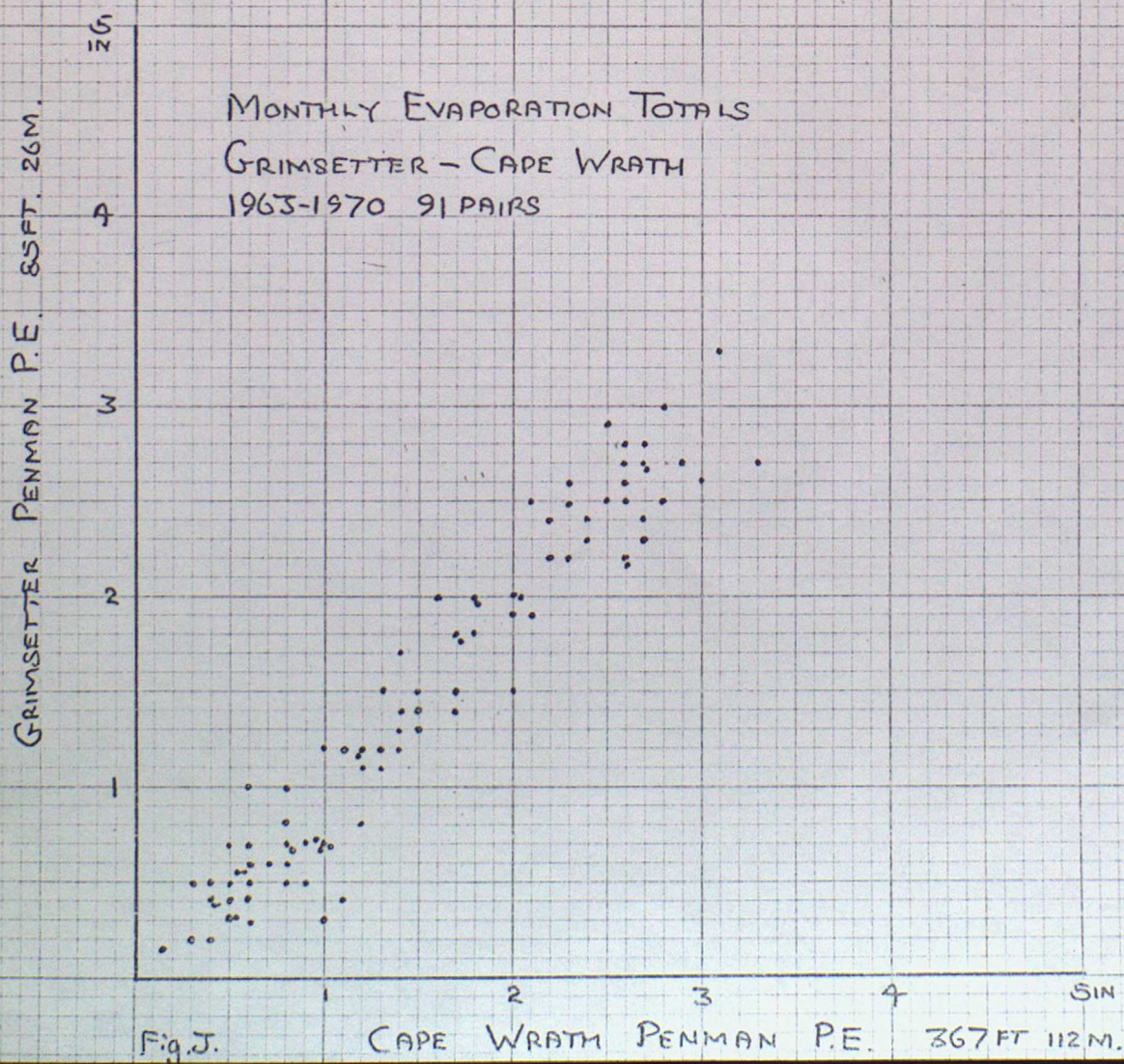
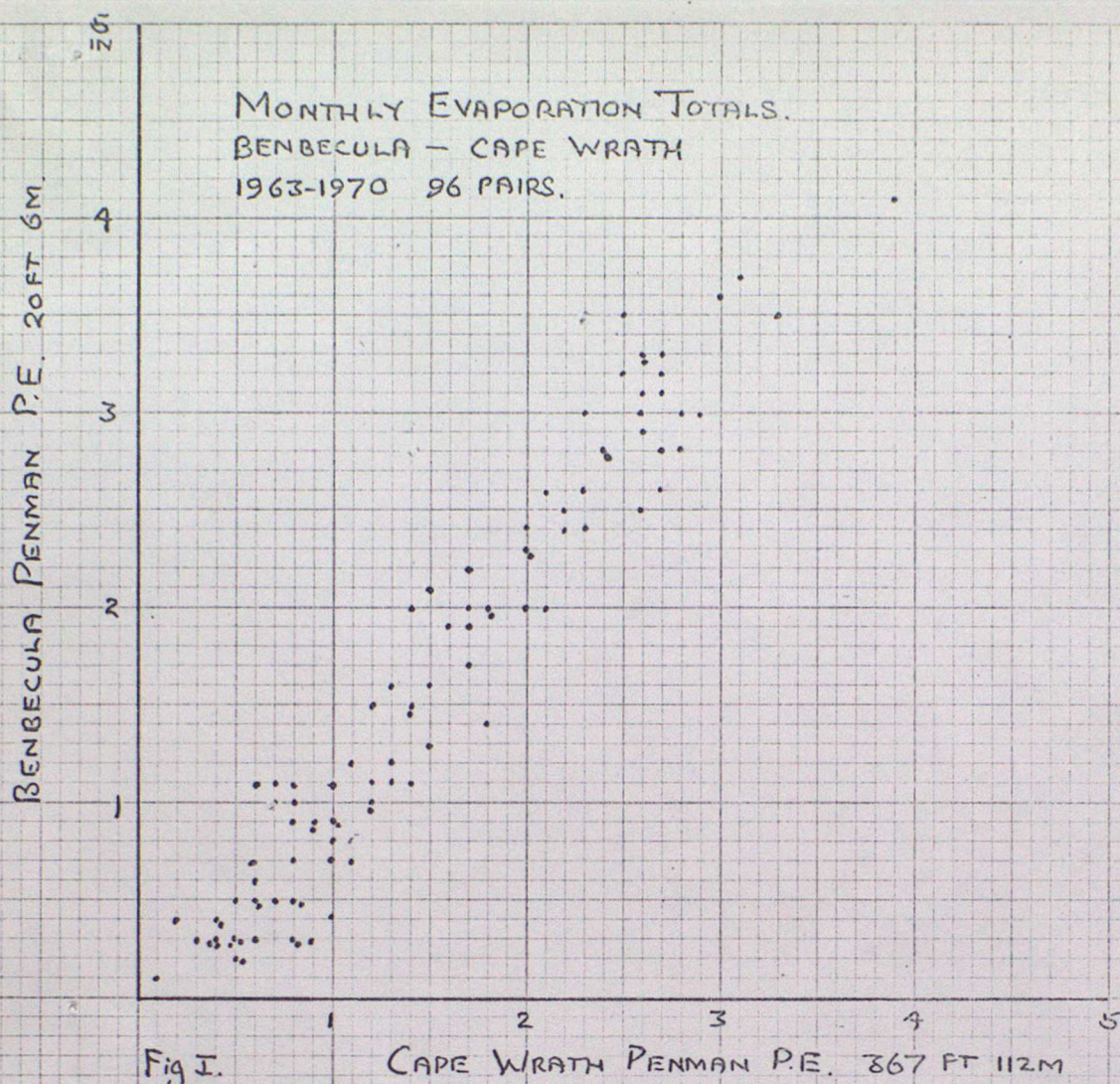
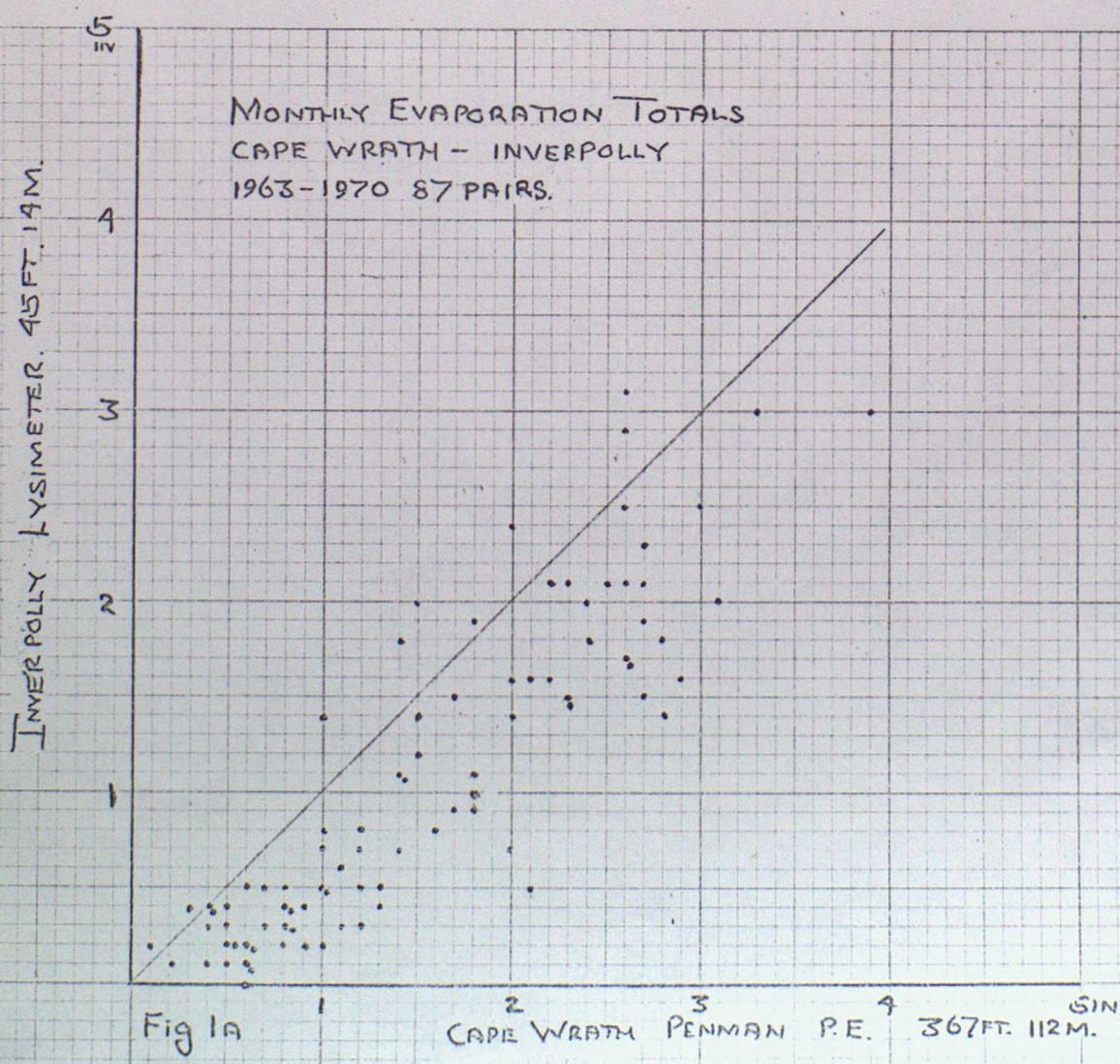
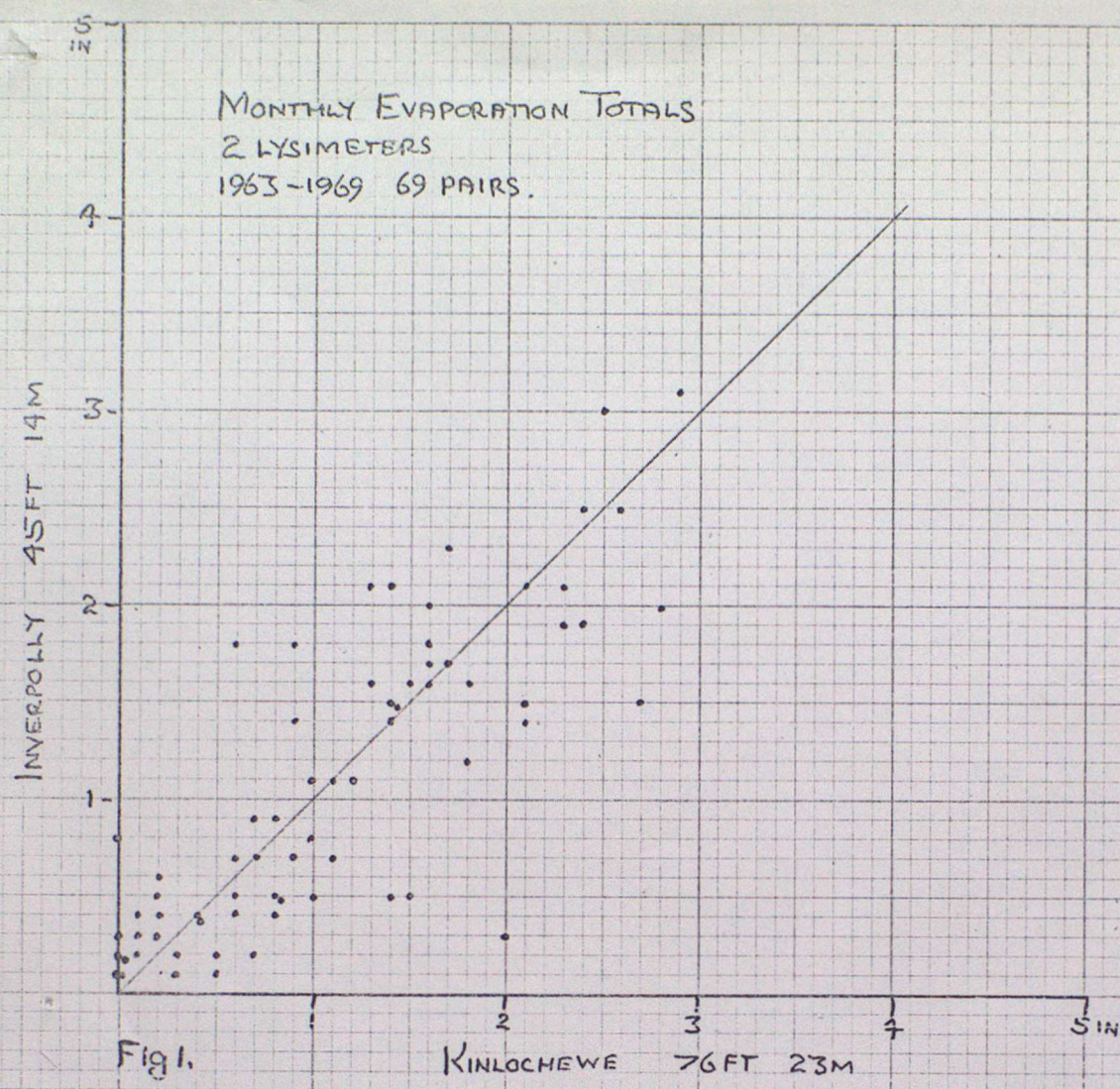


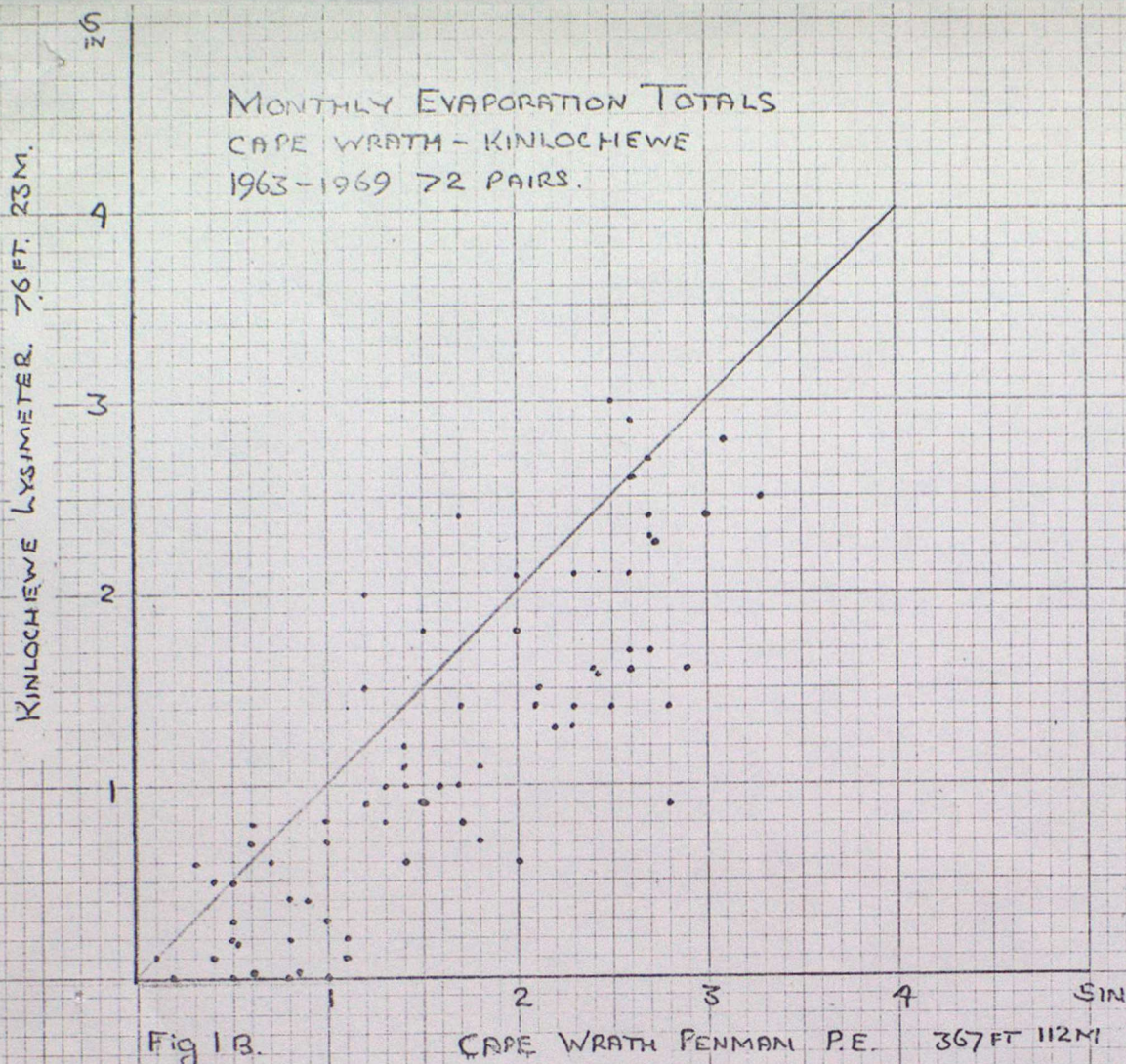
Fig. H.

UPAVON PENMAN P.E. 450 FT 137M.

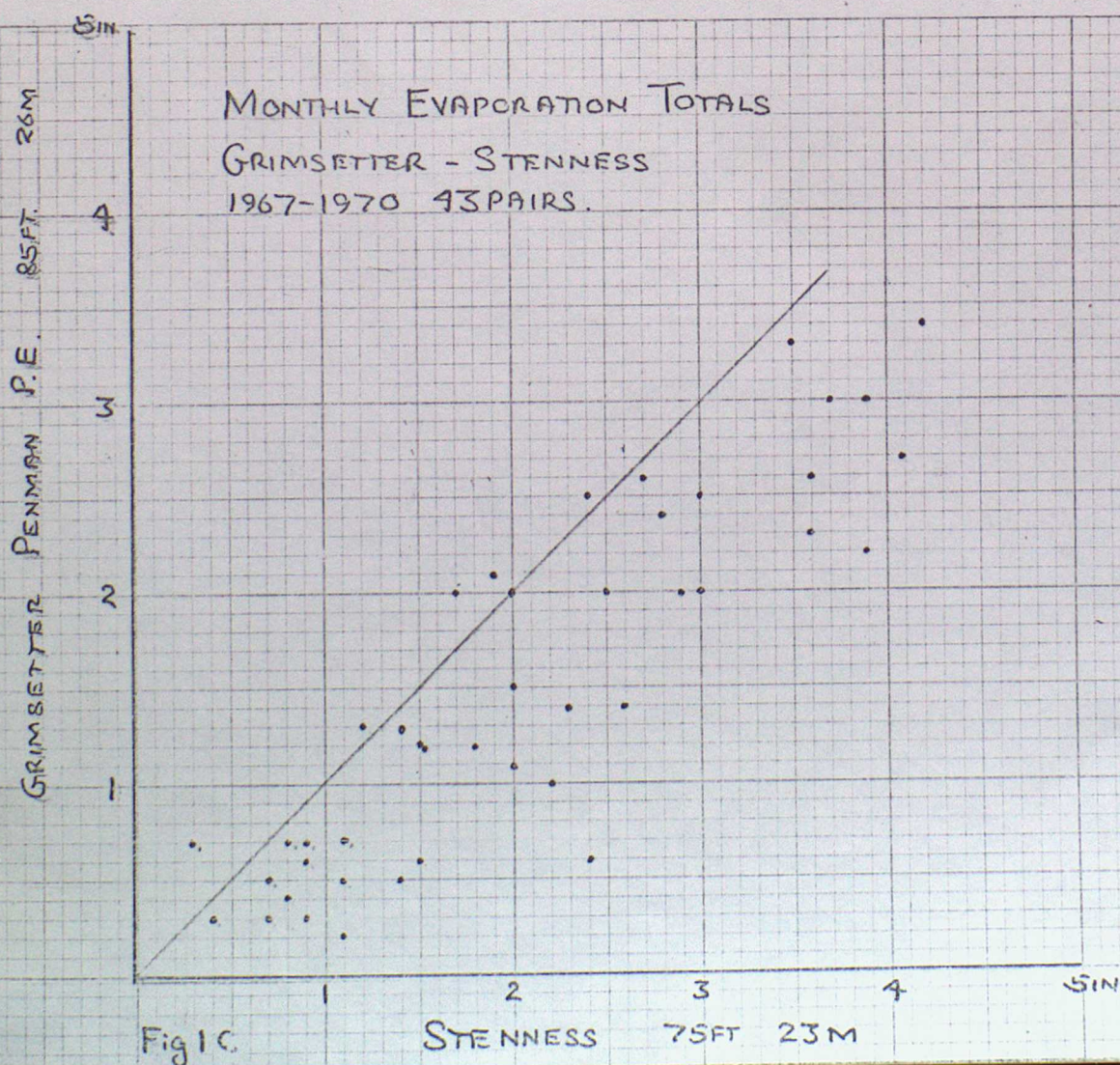


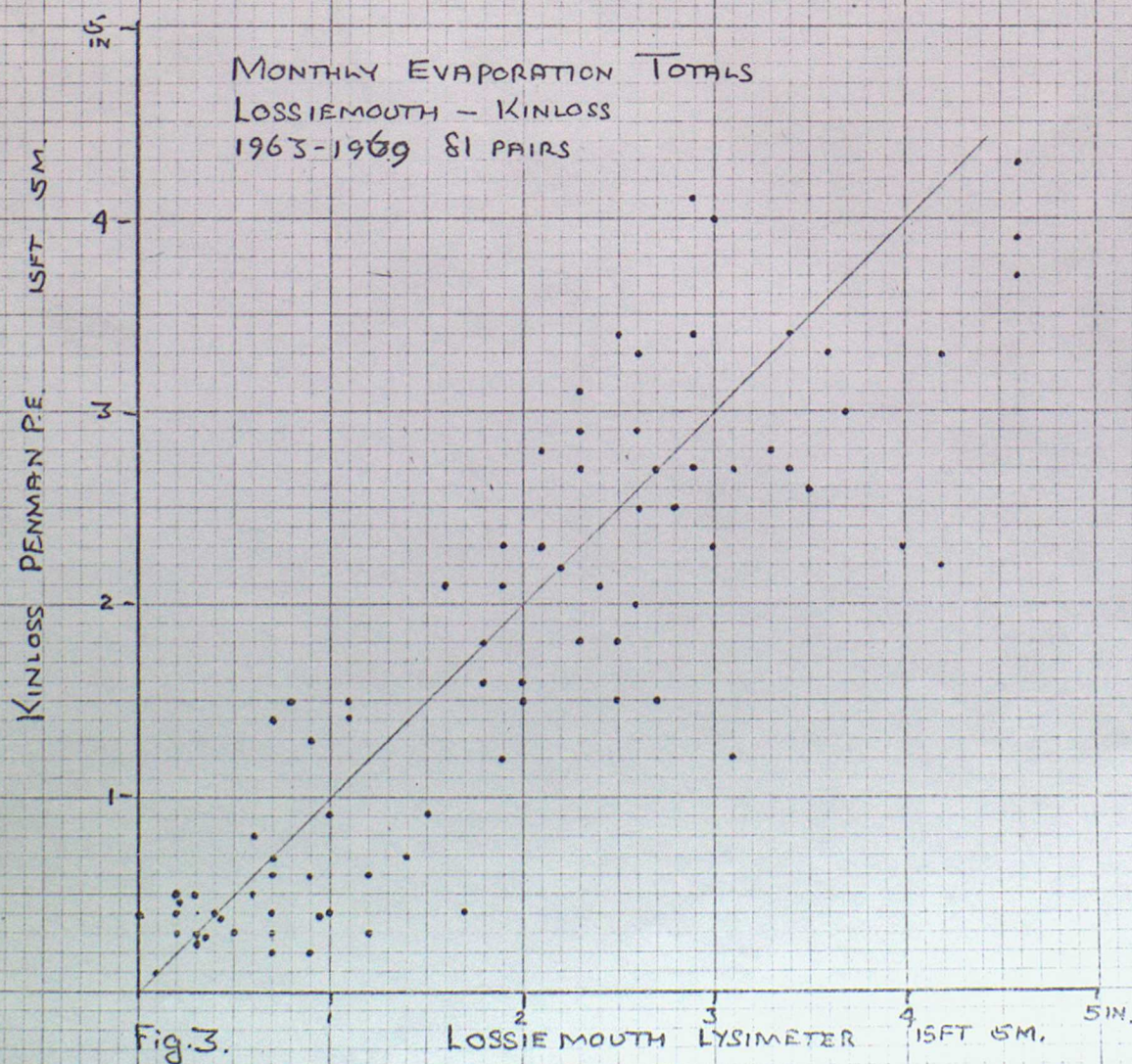
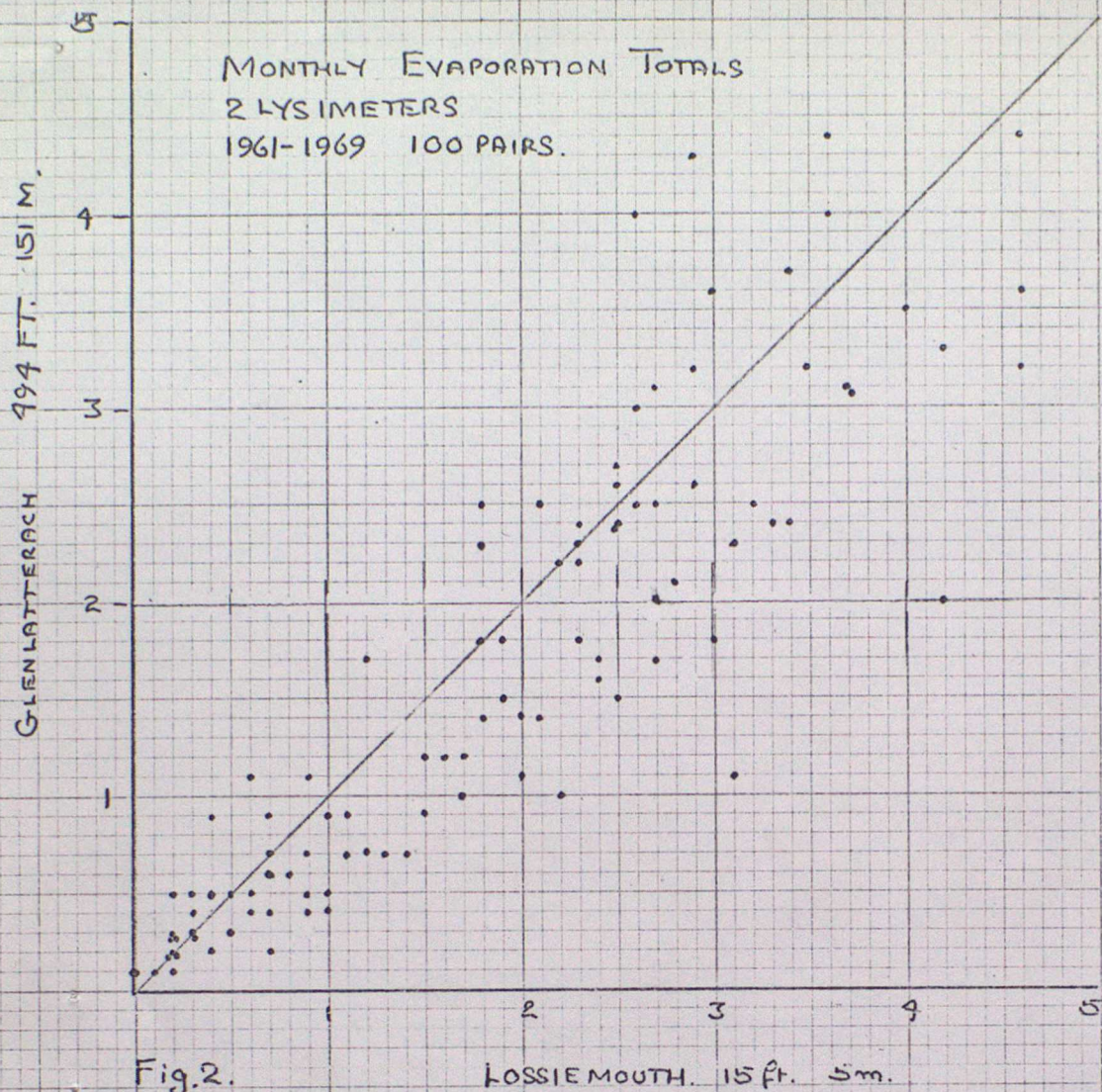


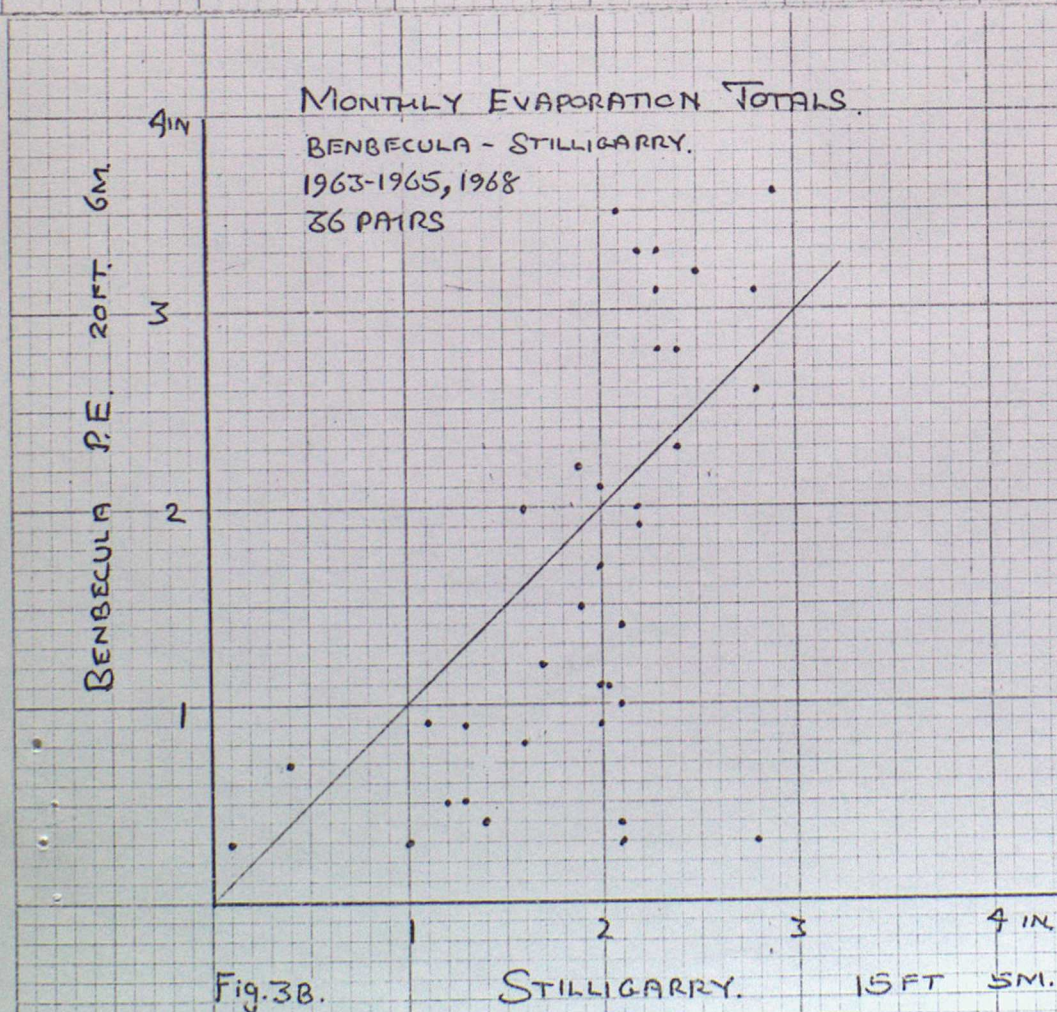
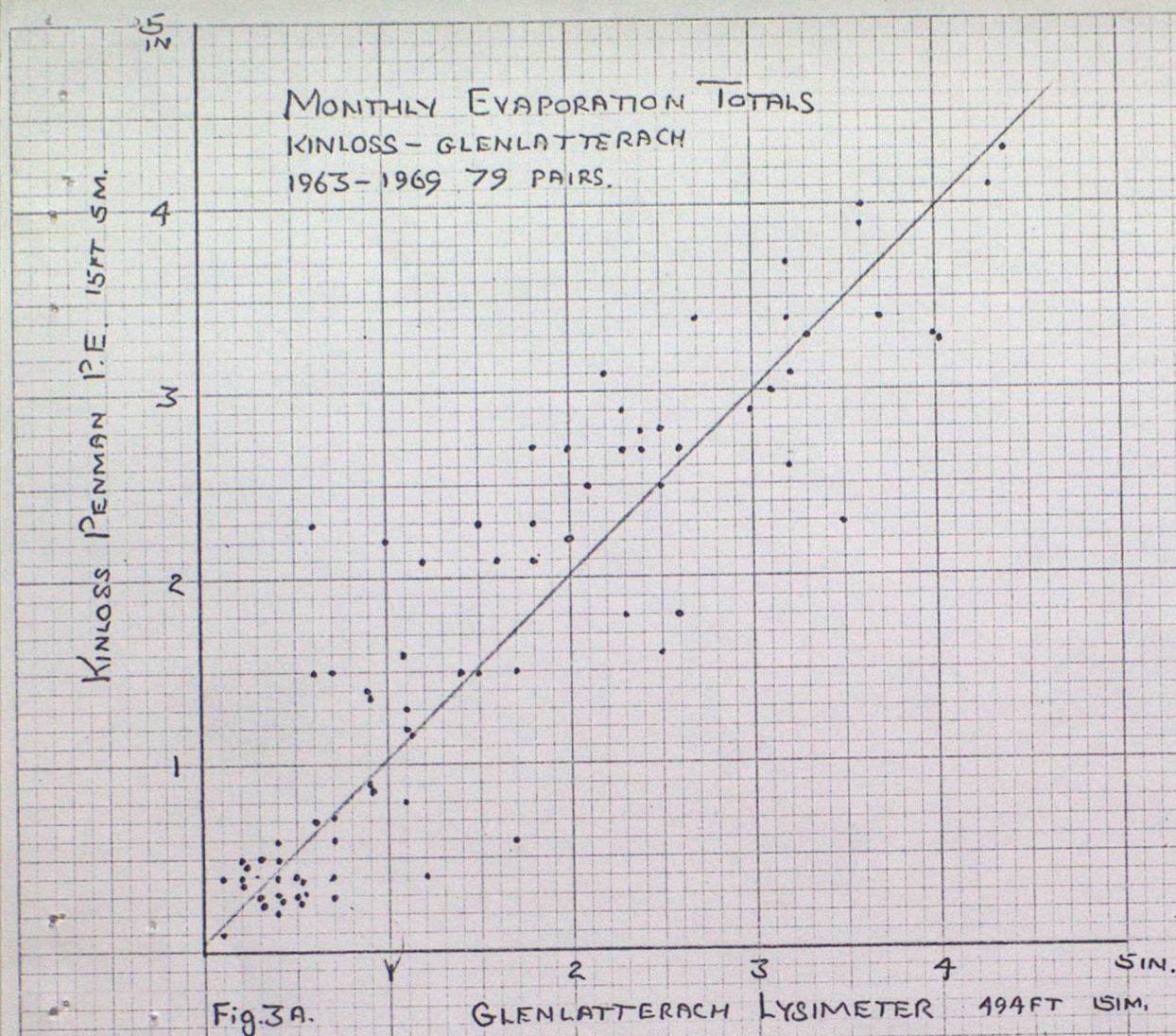
MONTHLY EVAPORATION TOTALS
CAPE WRATH - KINLOCHIEWE
1963-1969 72 PAIRS.

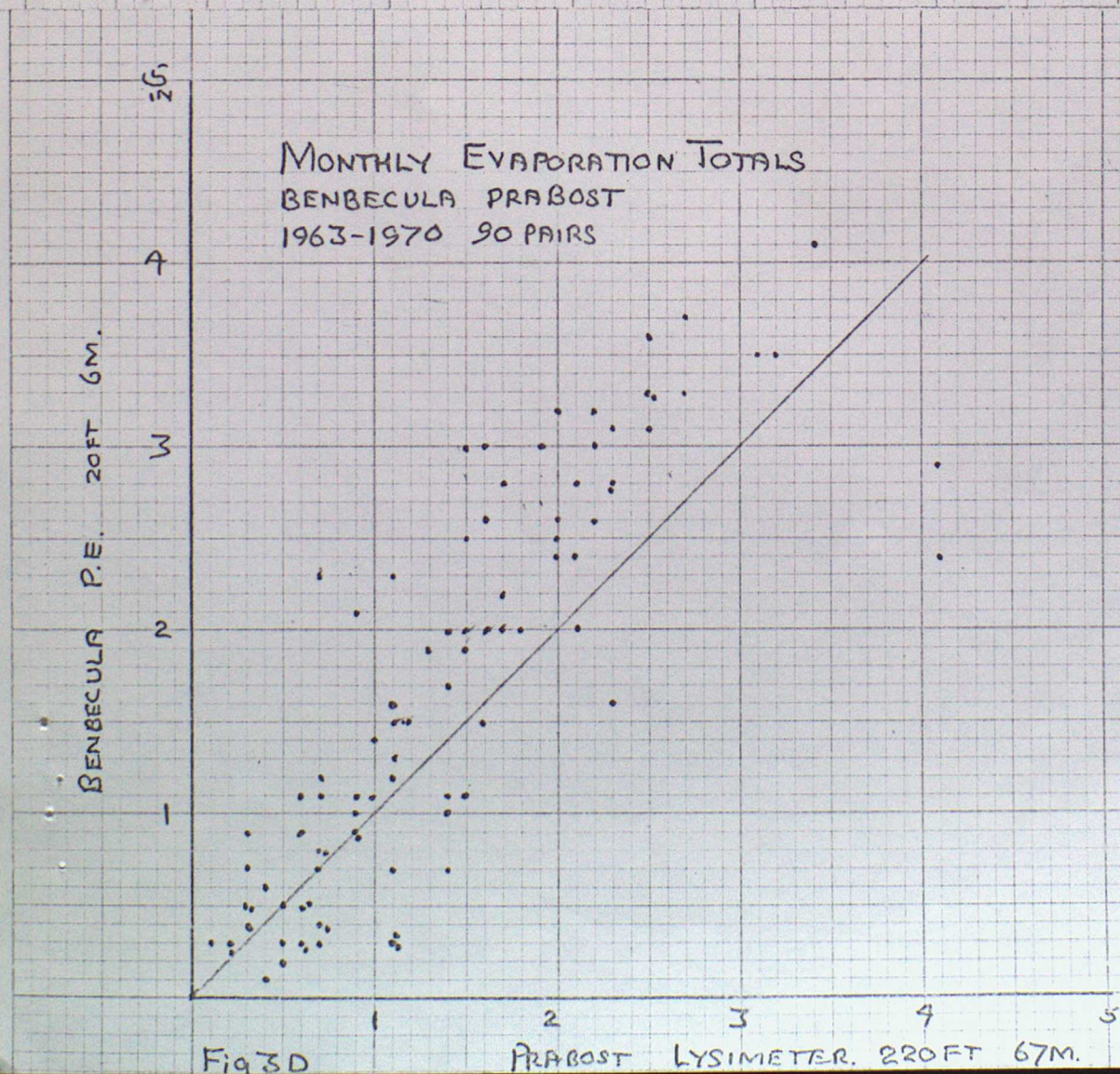
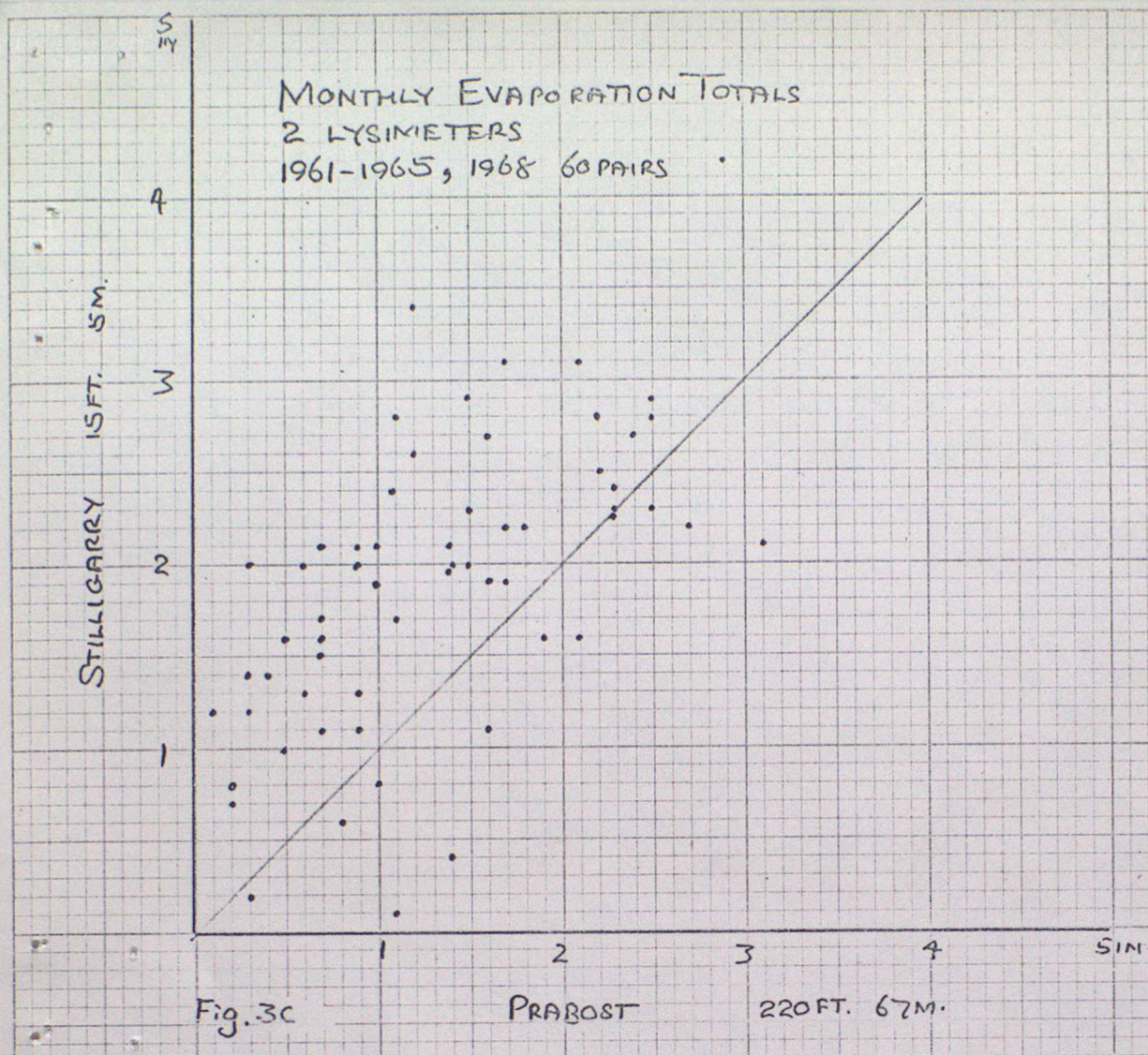


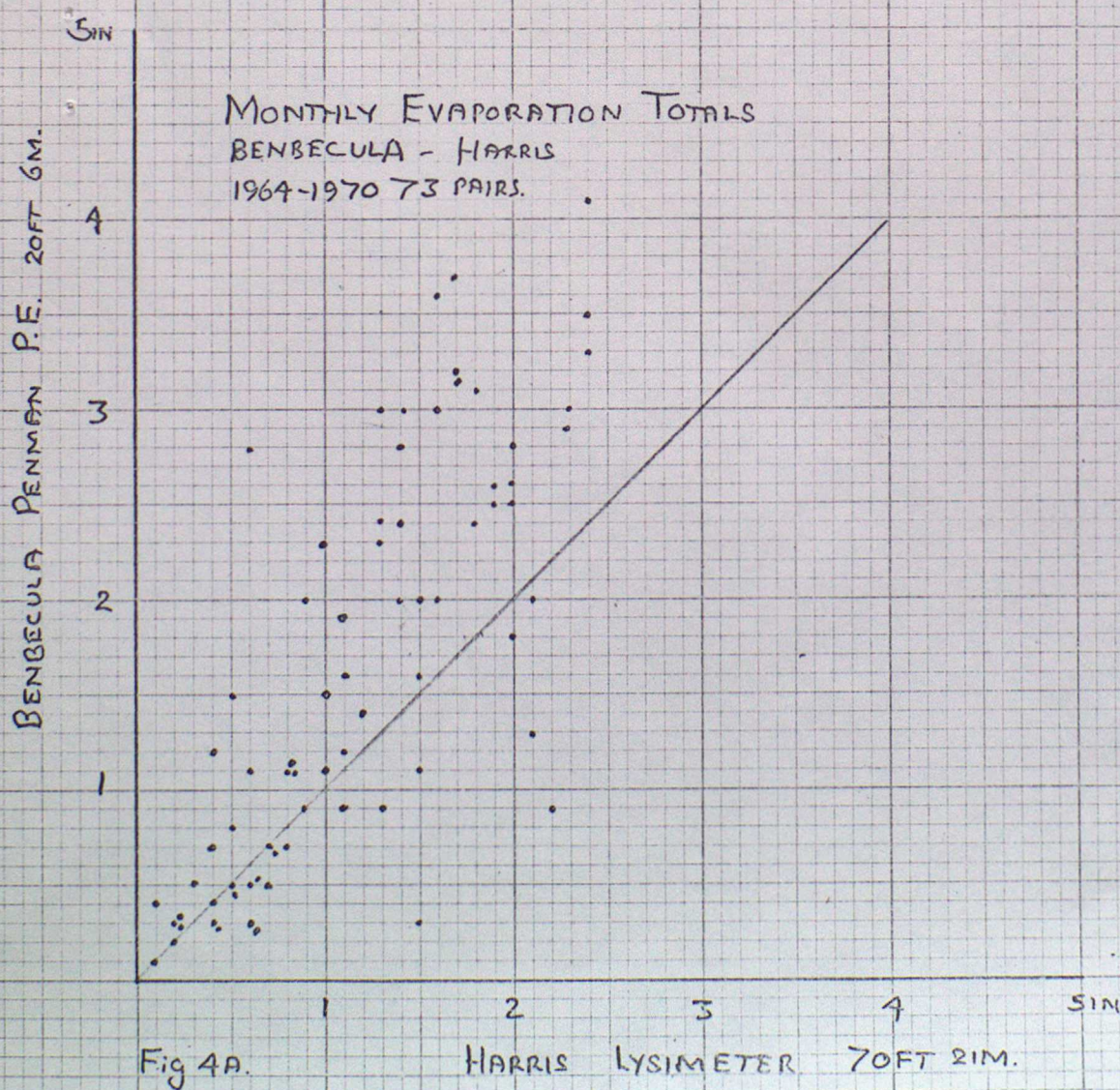
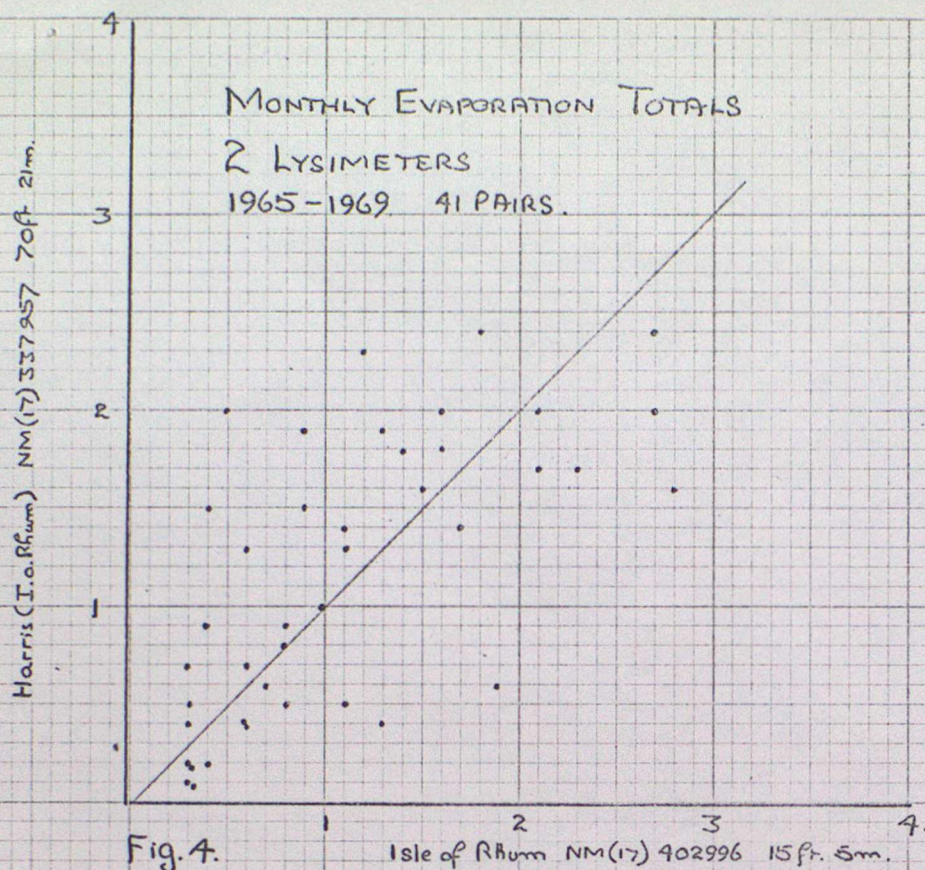
MONTHLY EVAPORATION TOTALS
GRIMSETTER - STENNESS
1967-1970 43 PAIRS.

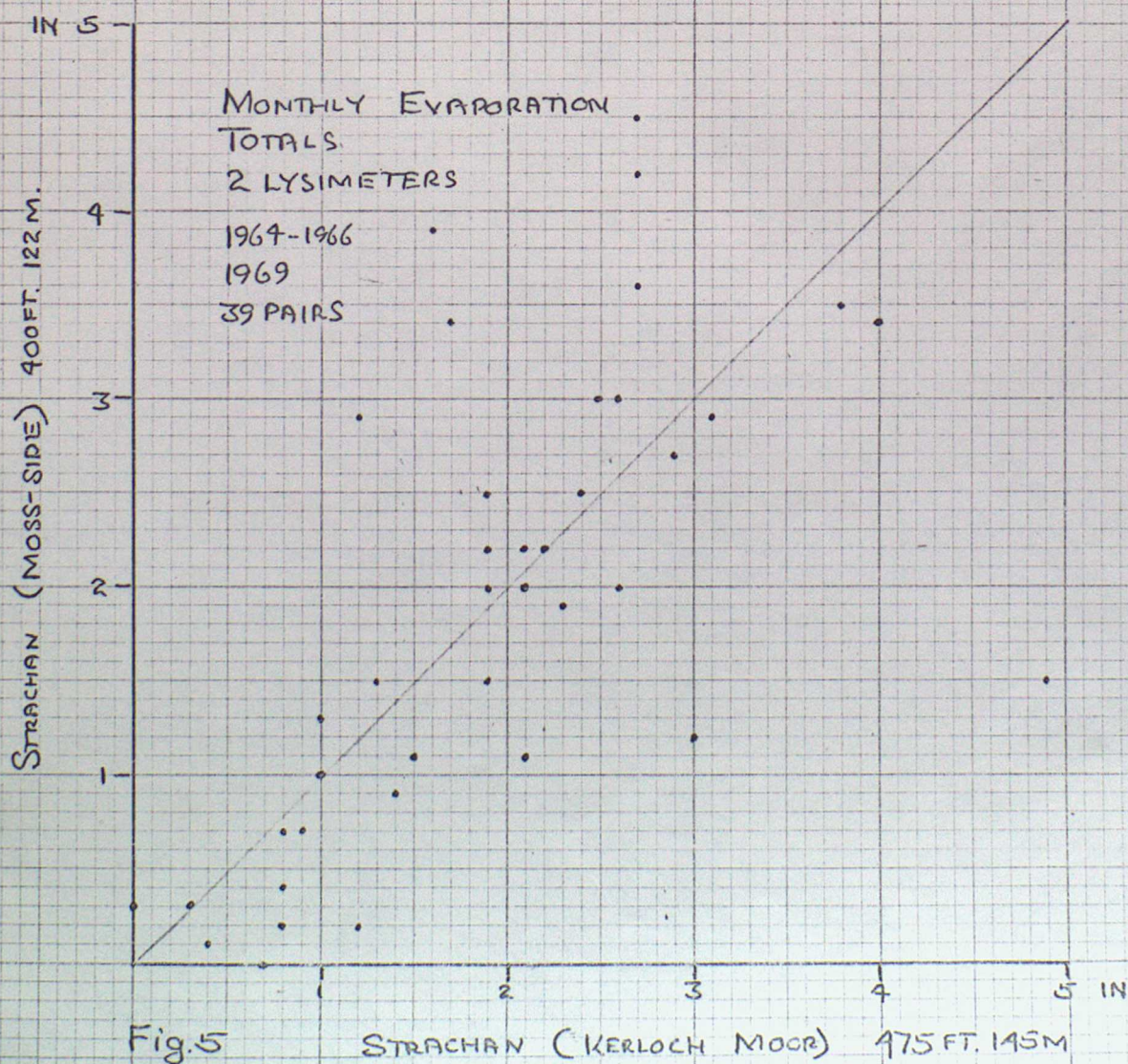
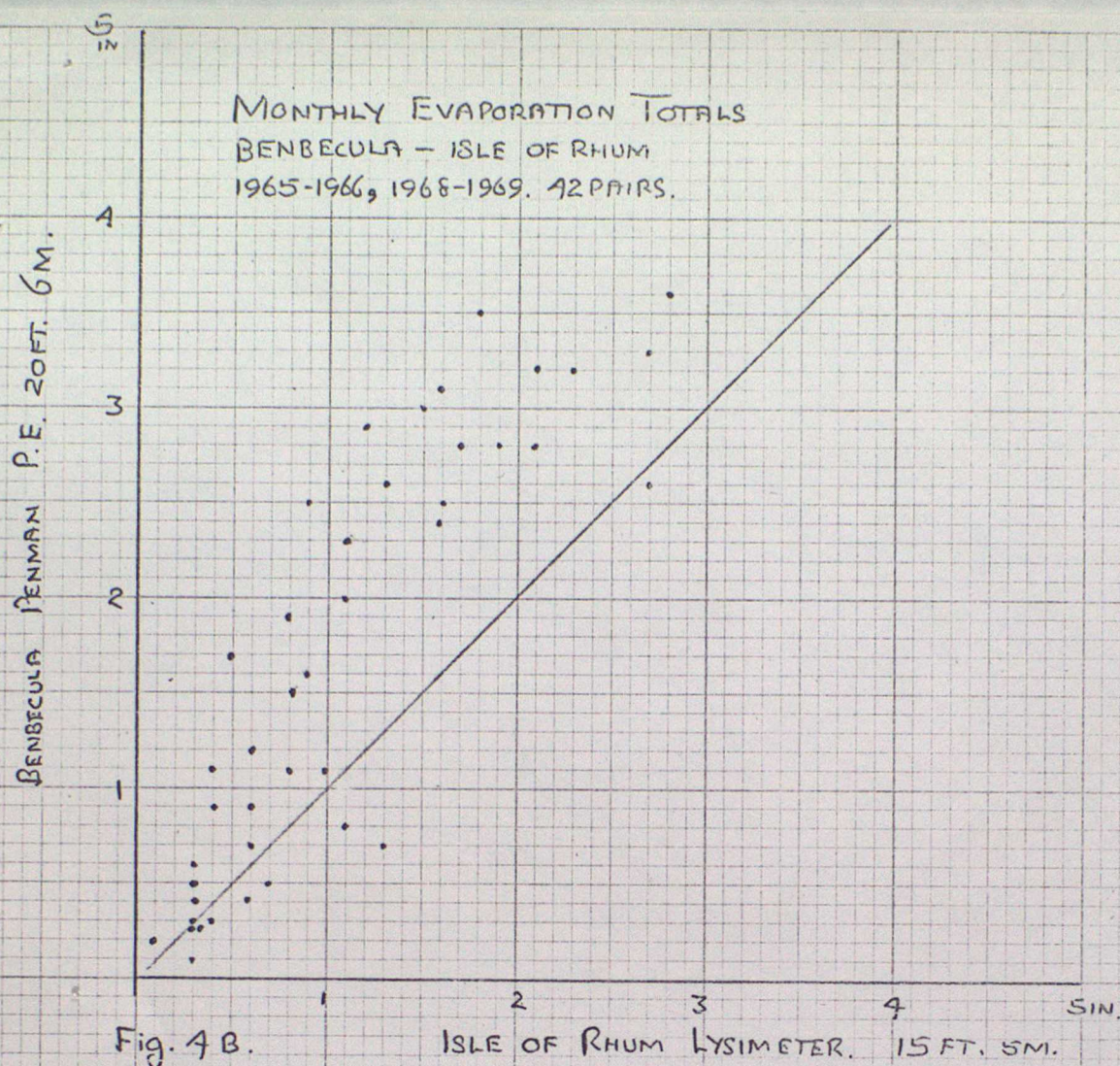


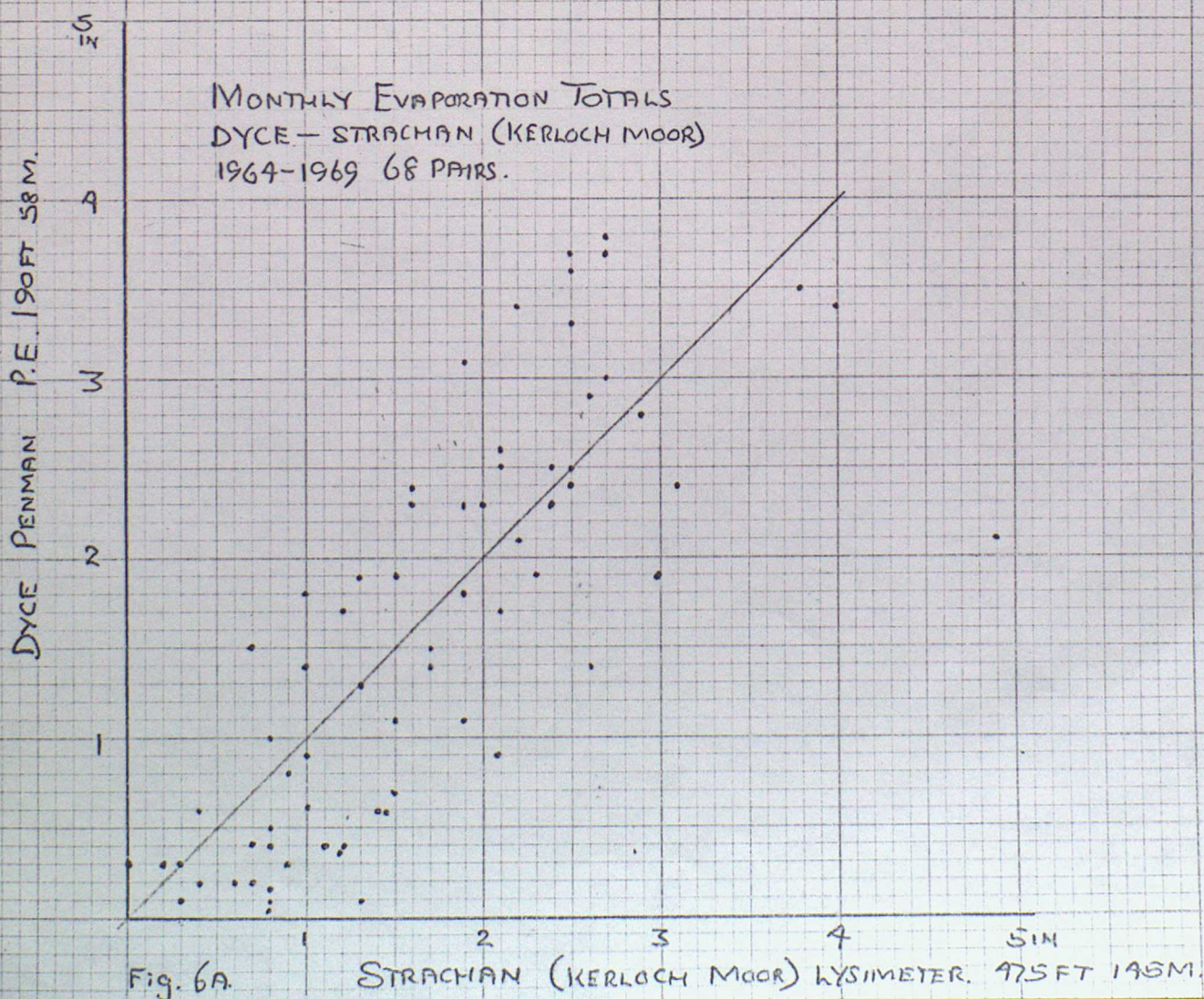
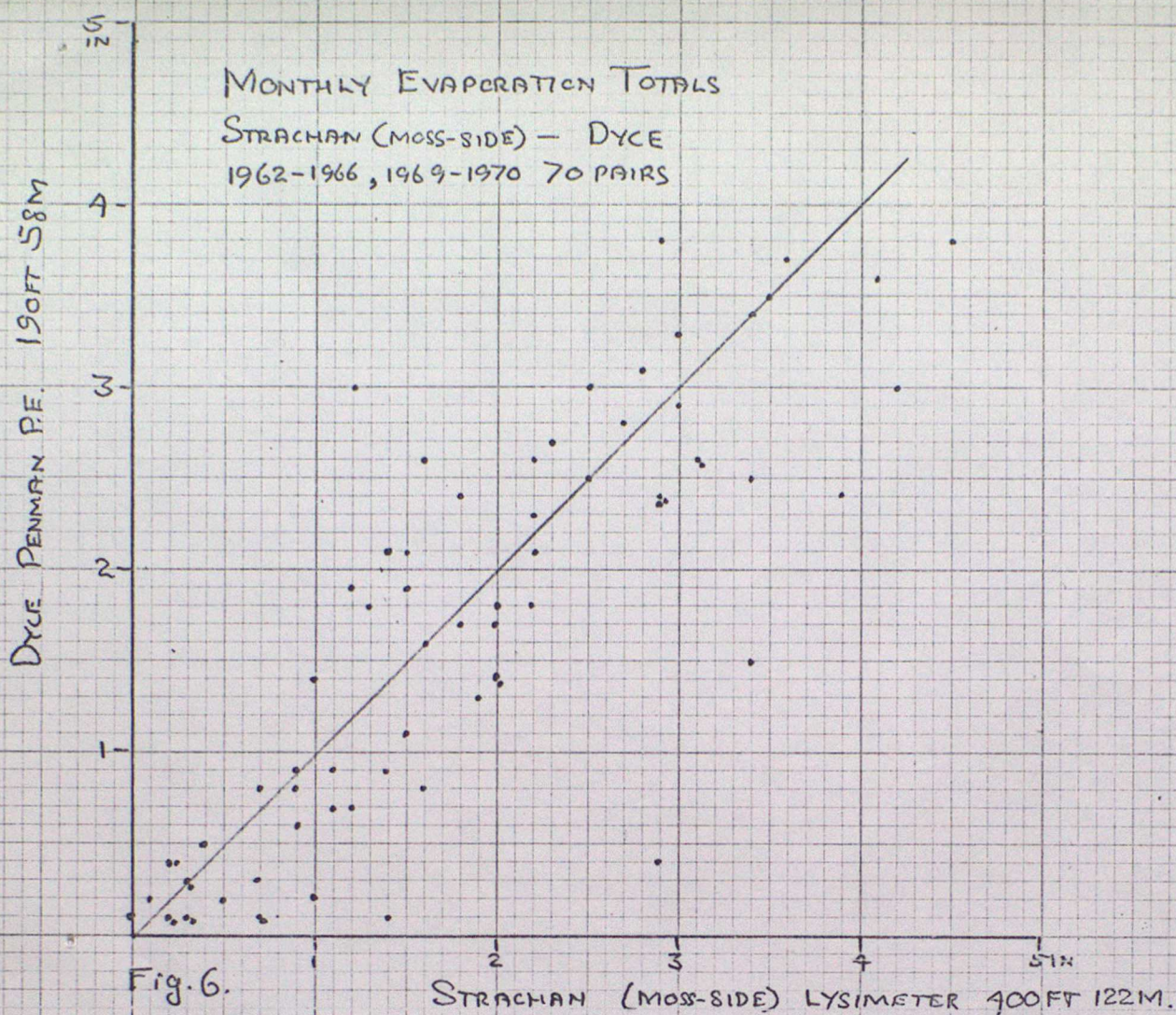


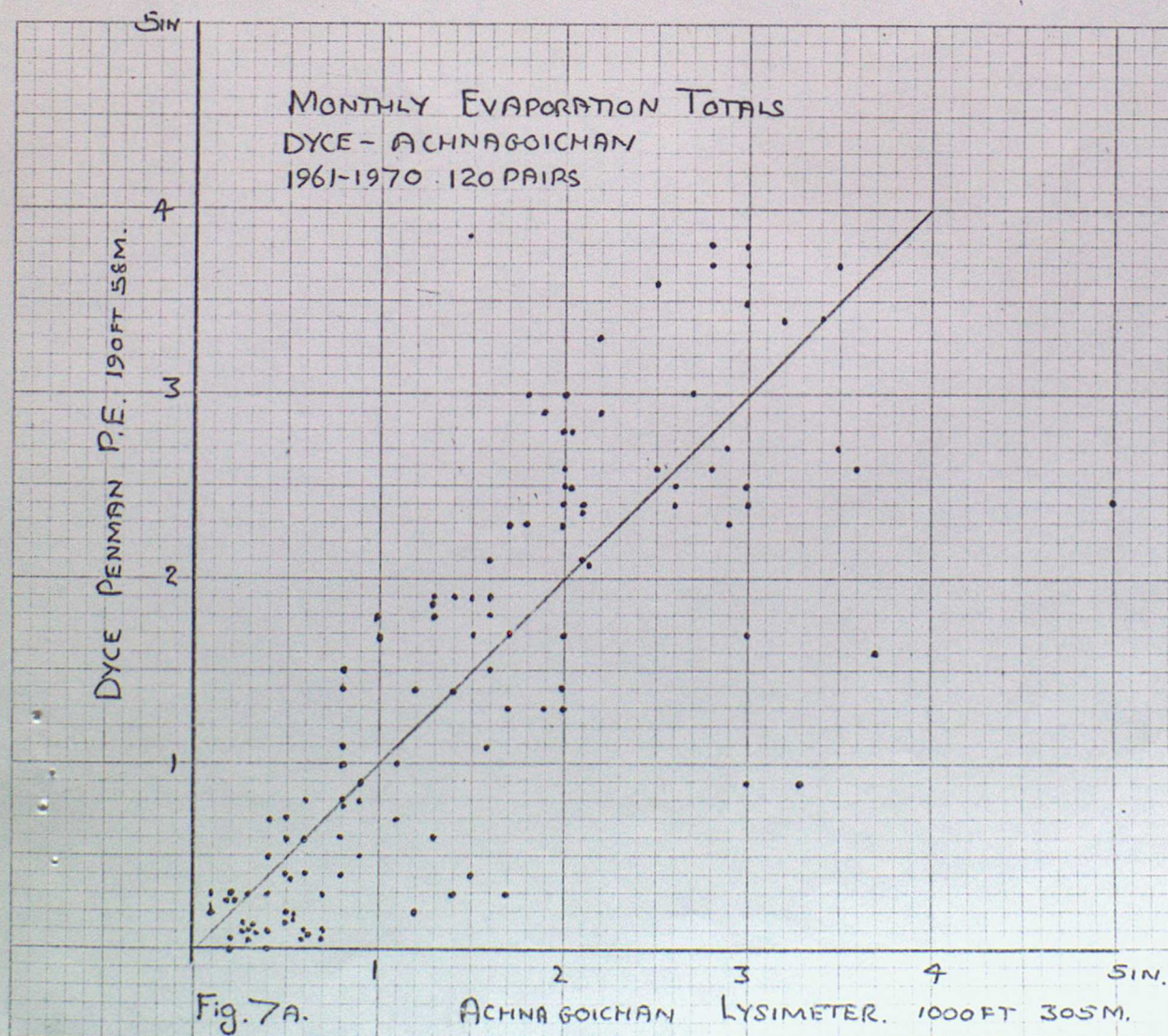
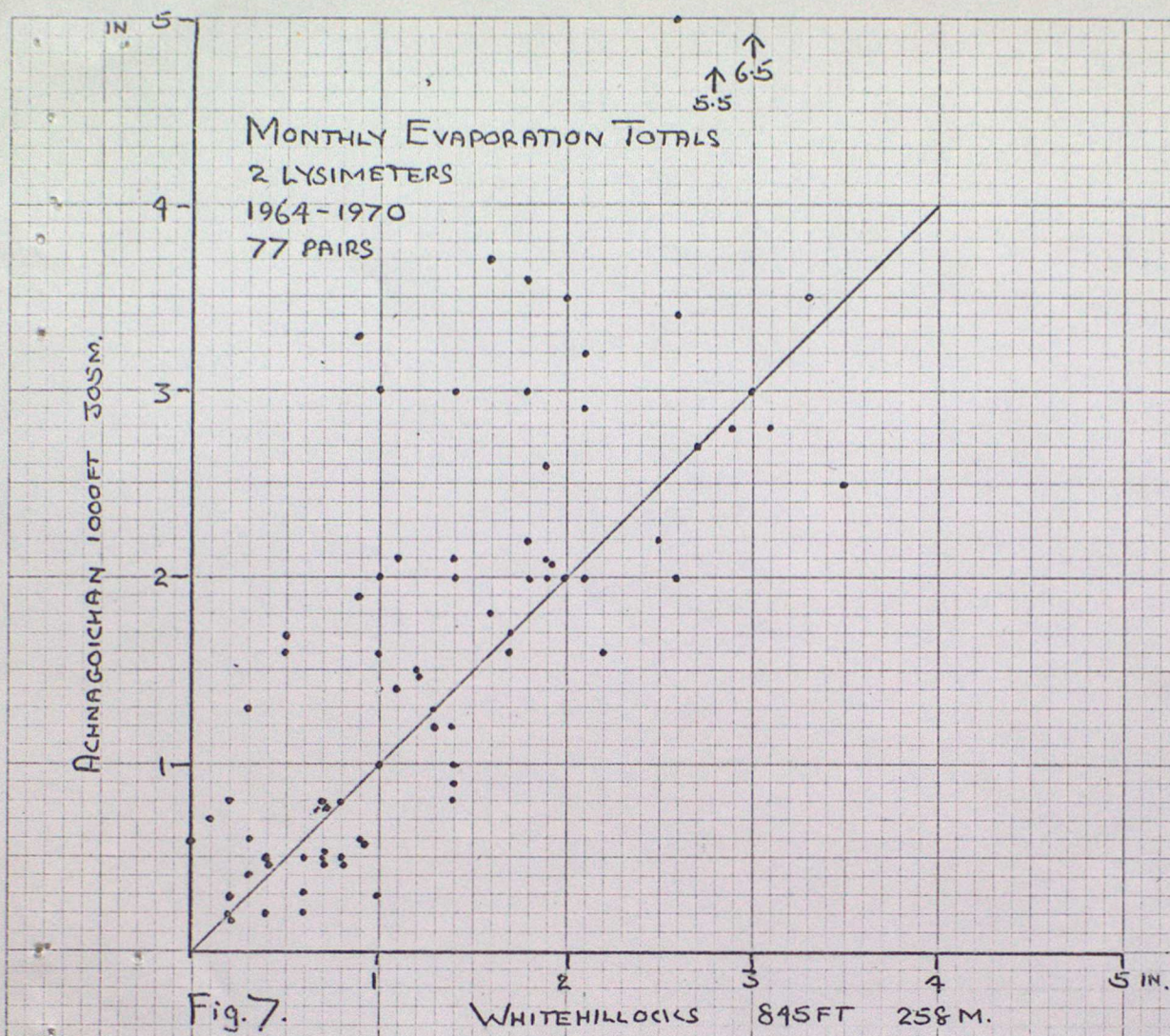


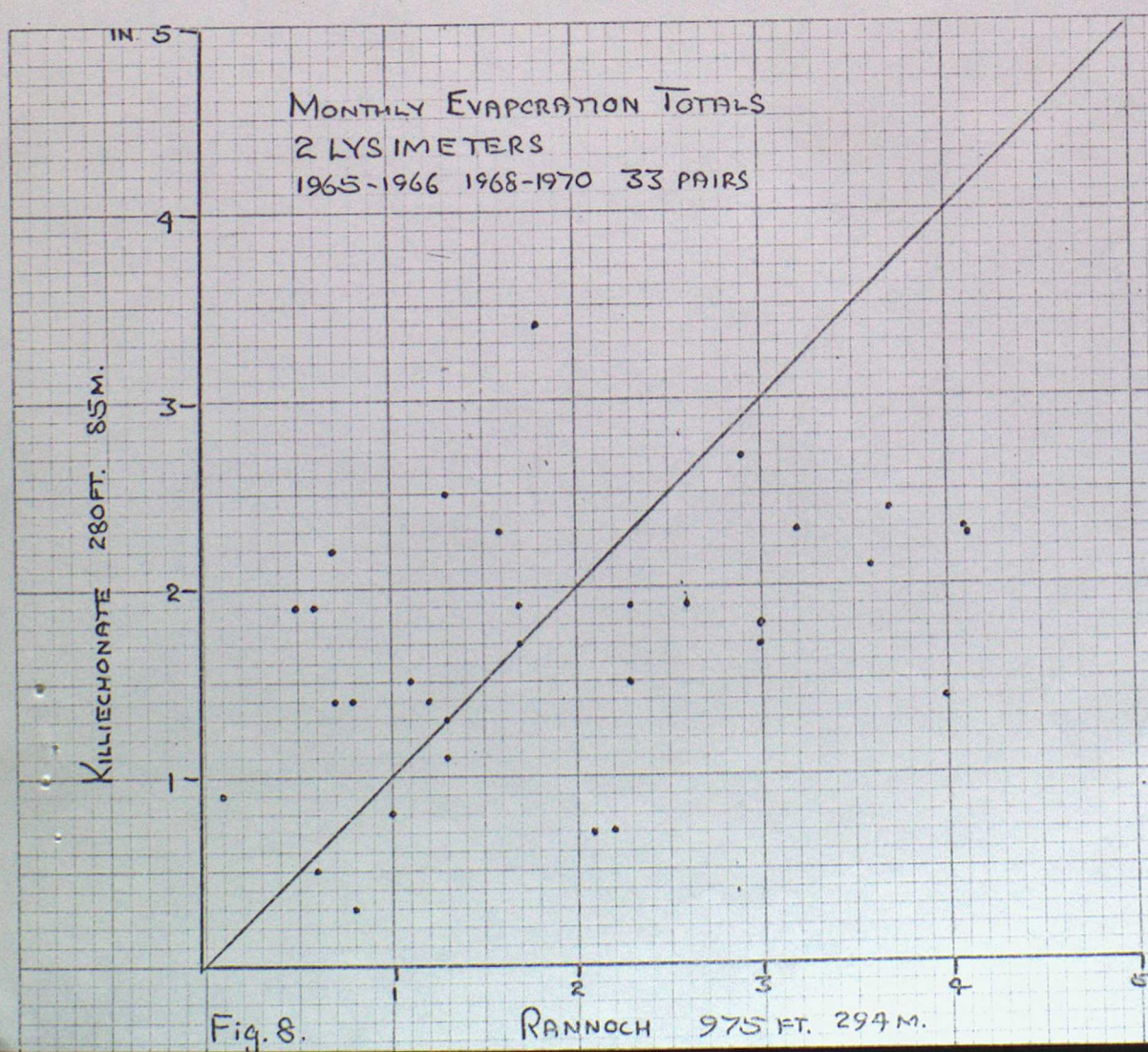
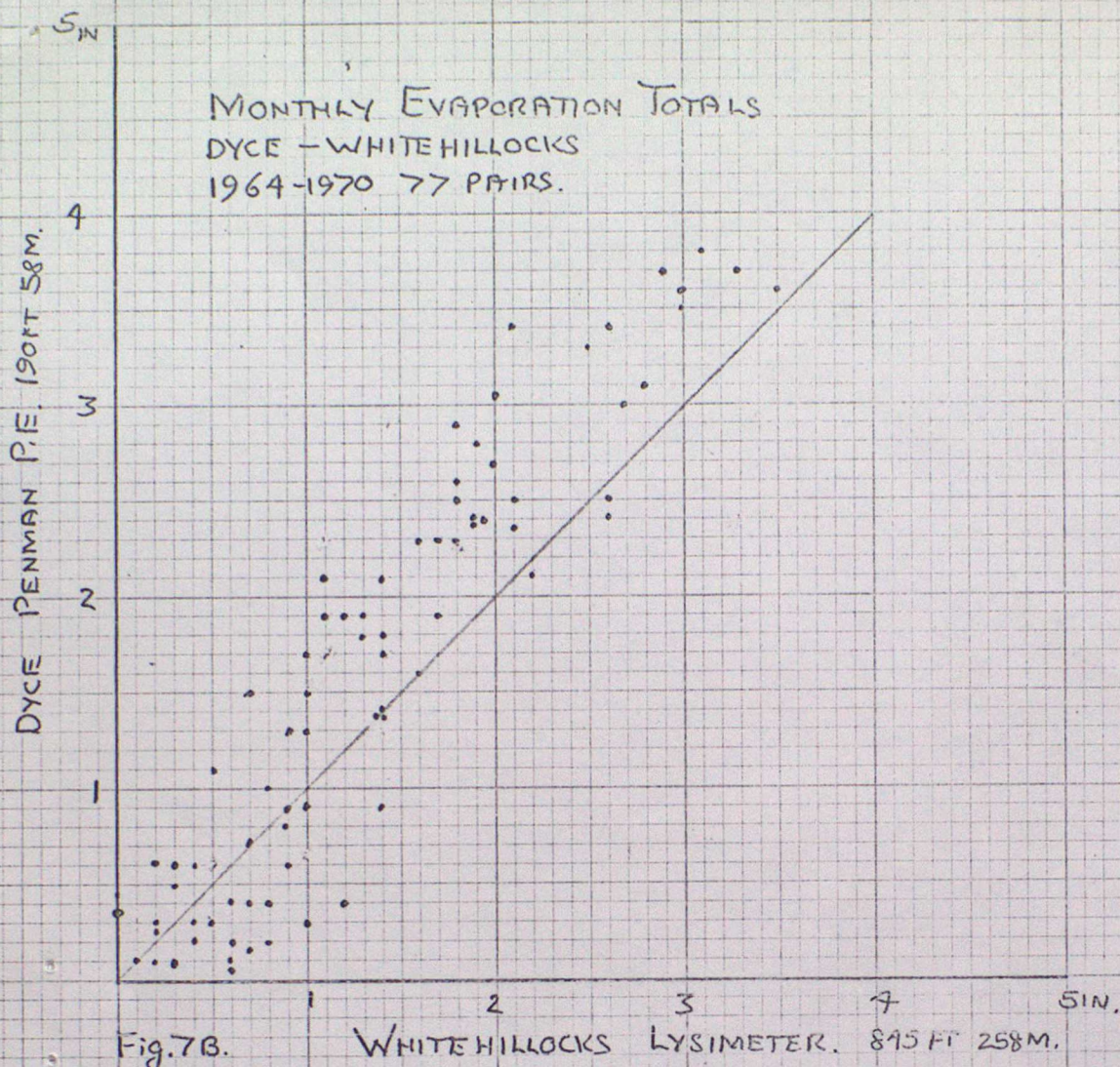


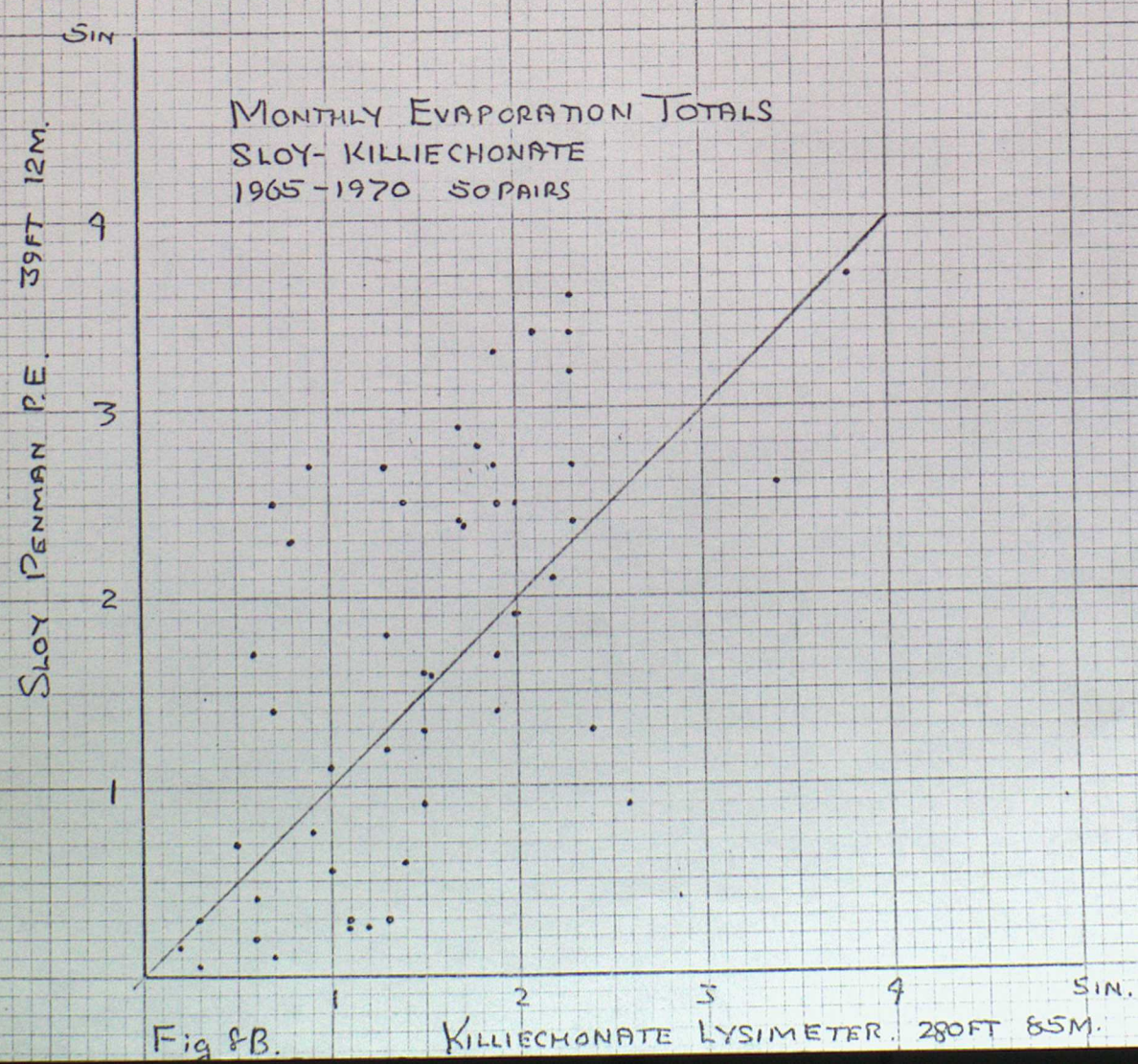
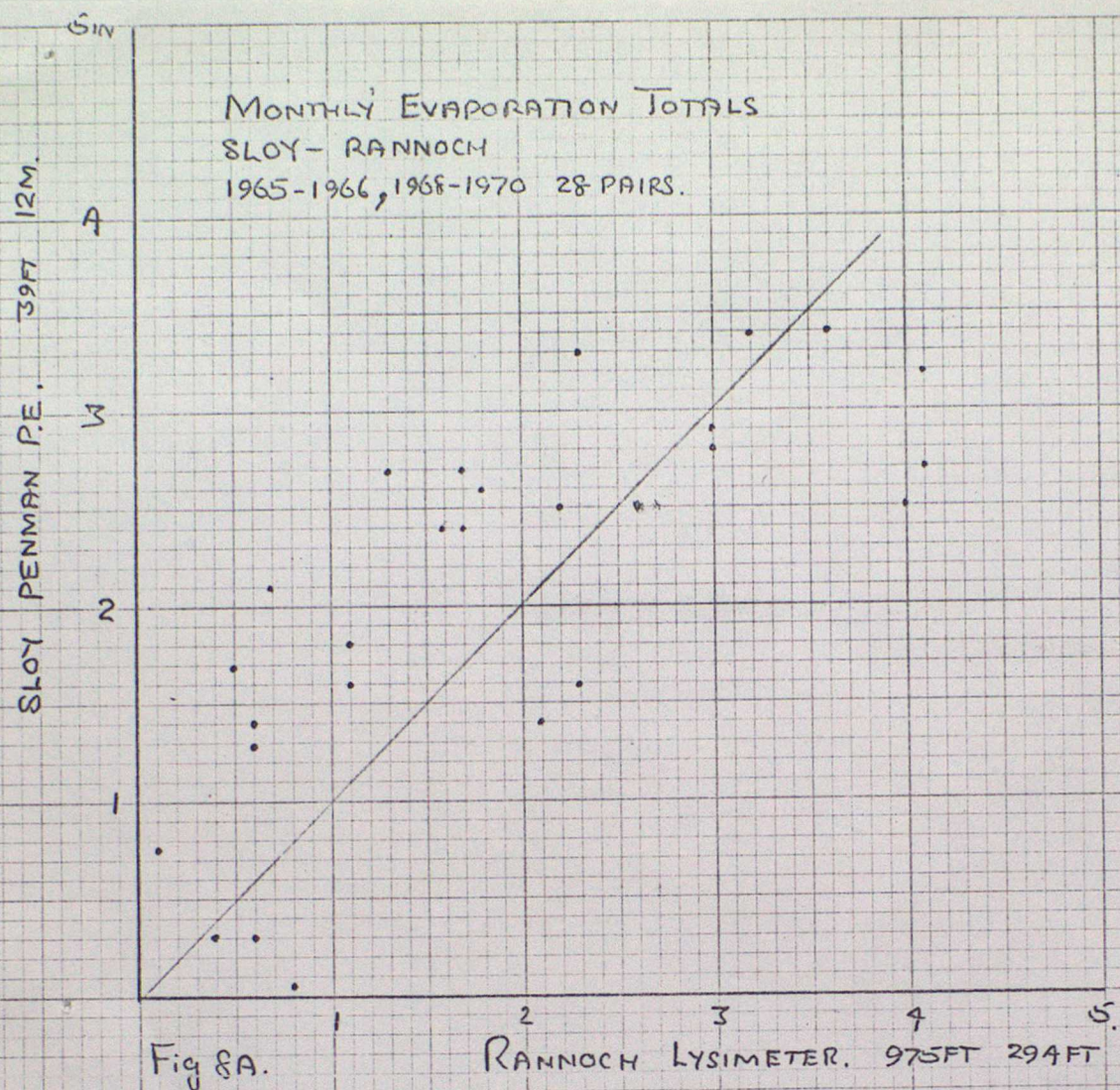


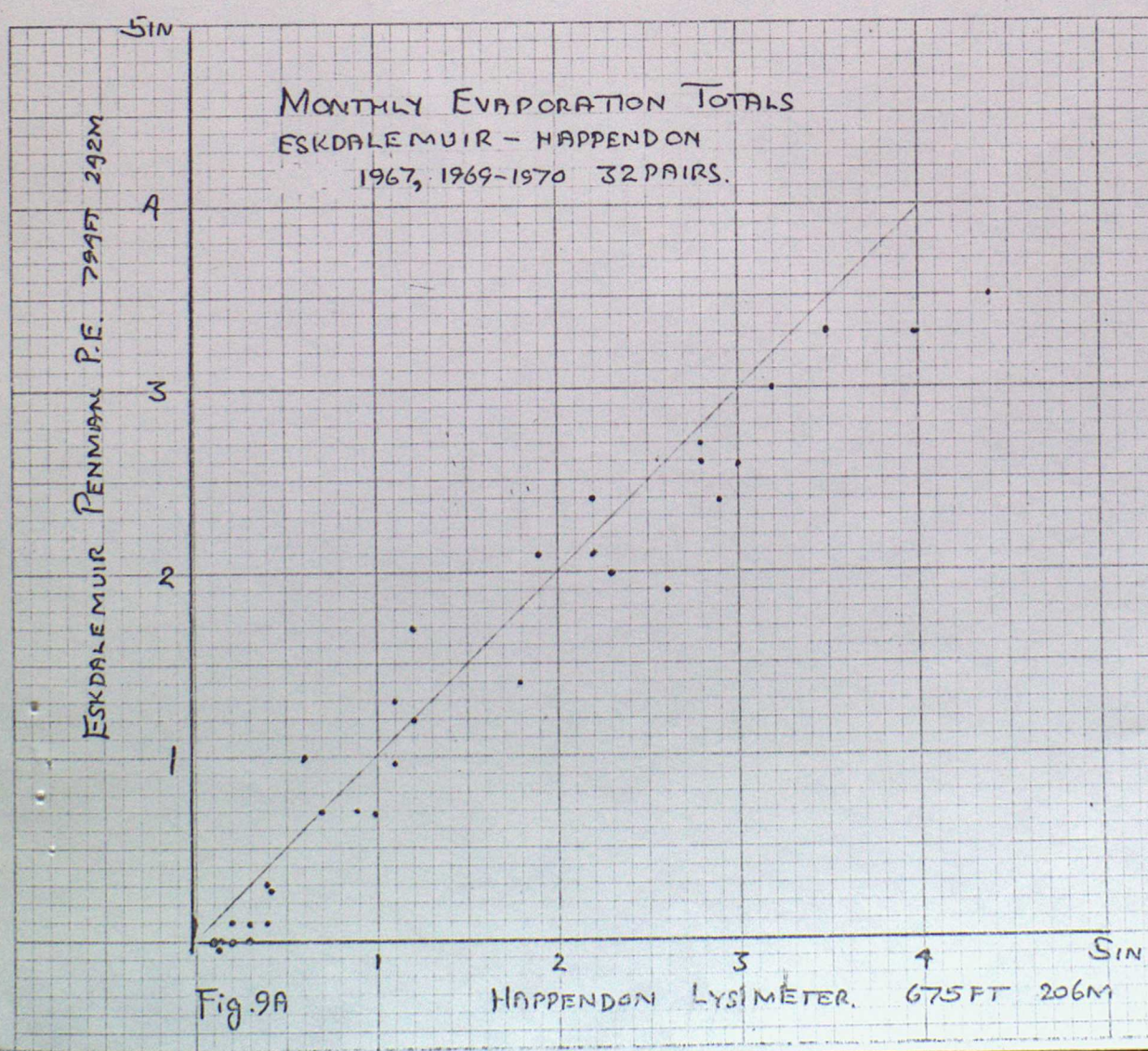
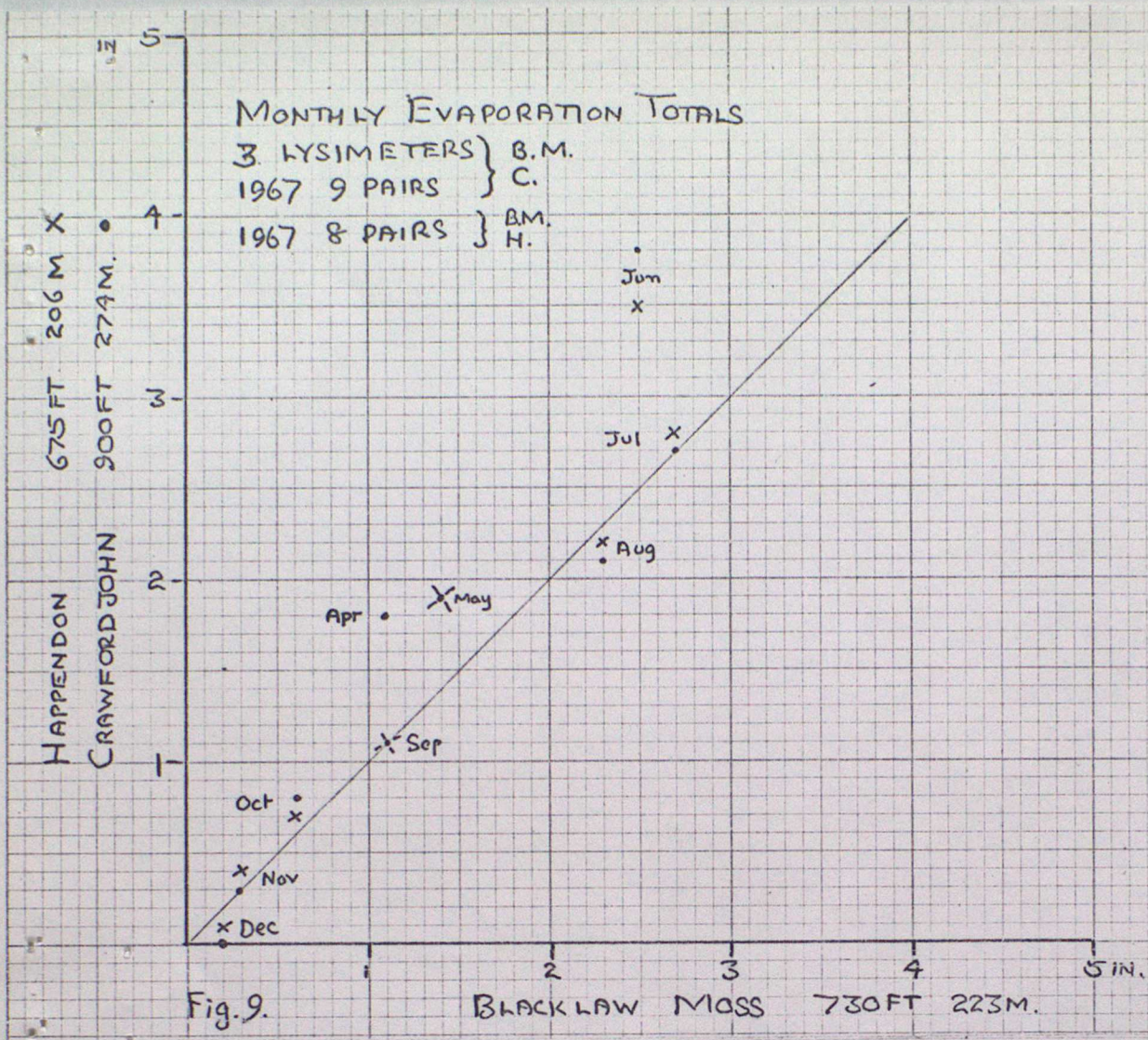


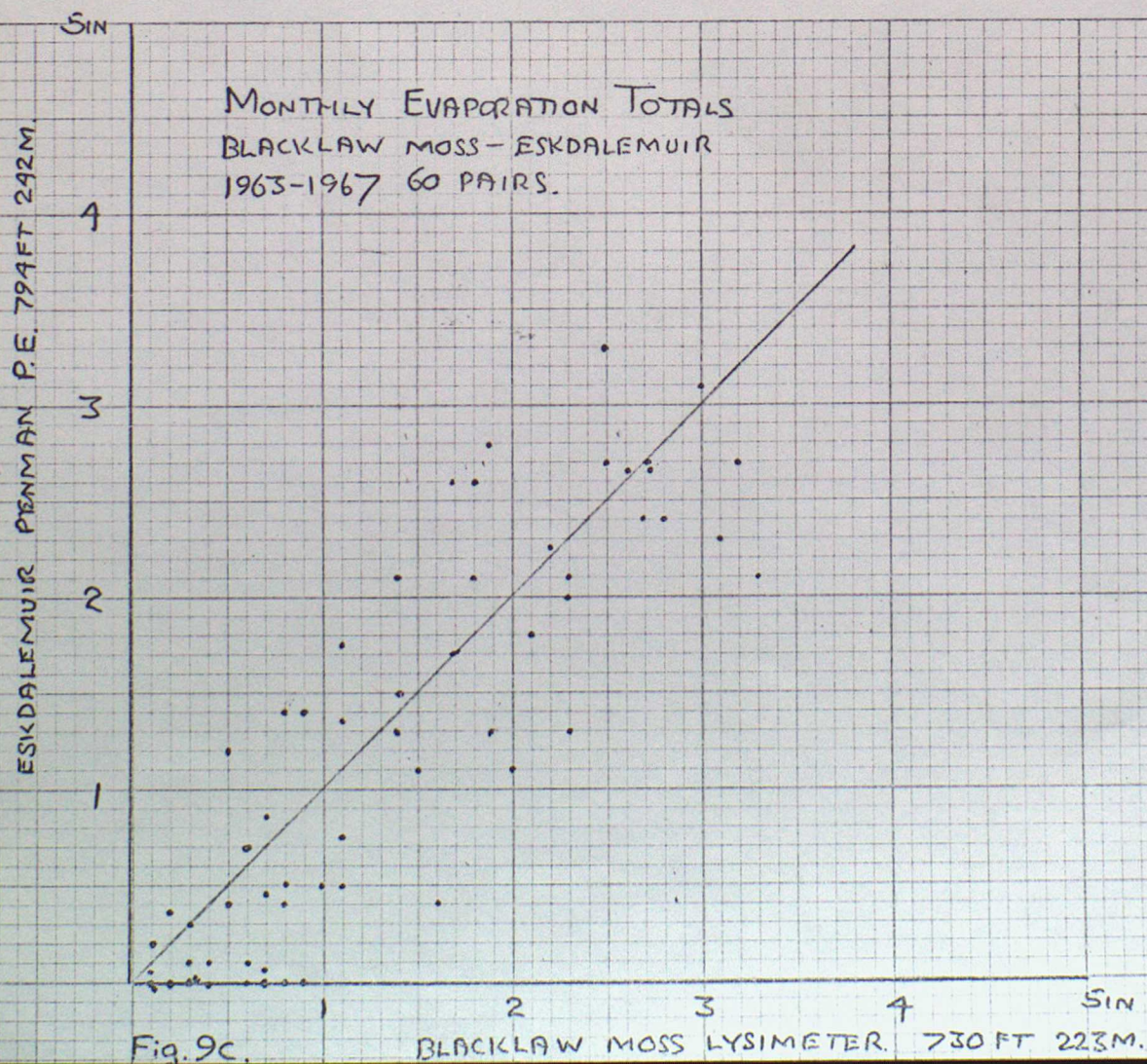
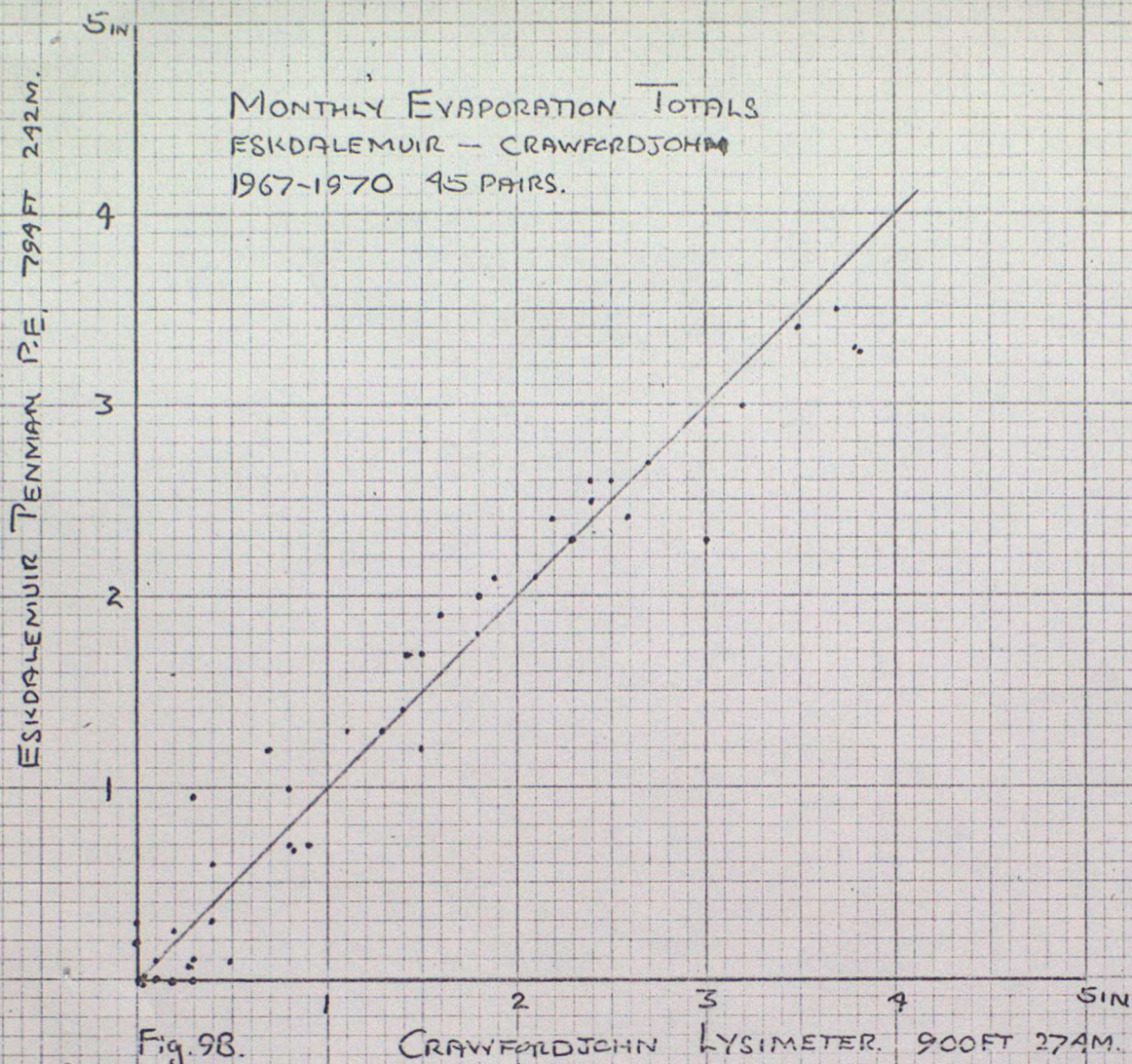


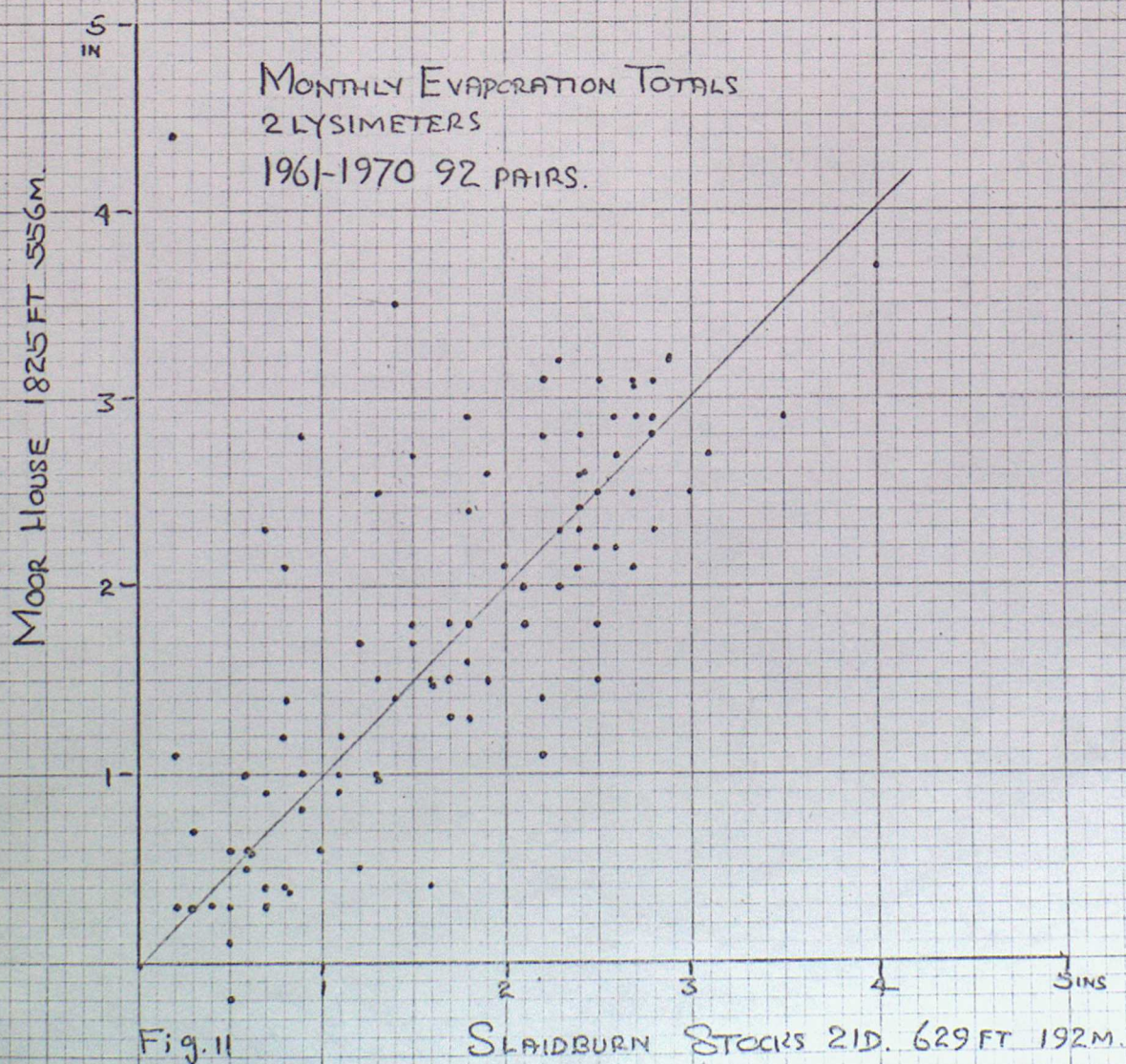
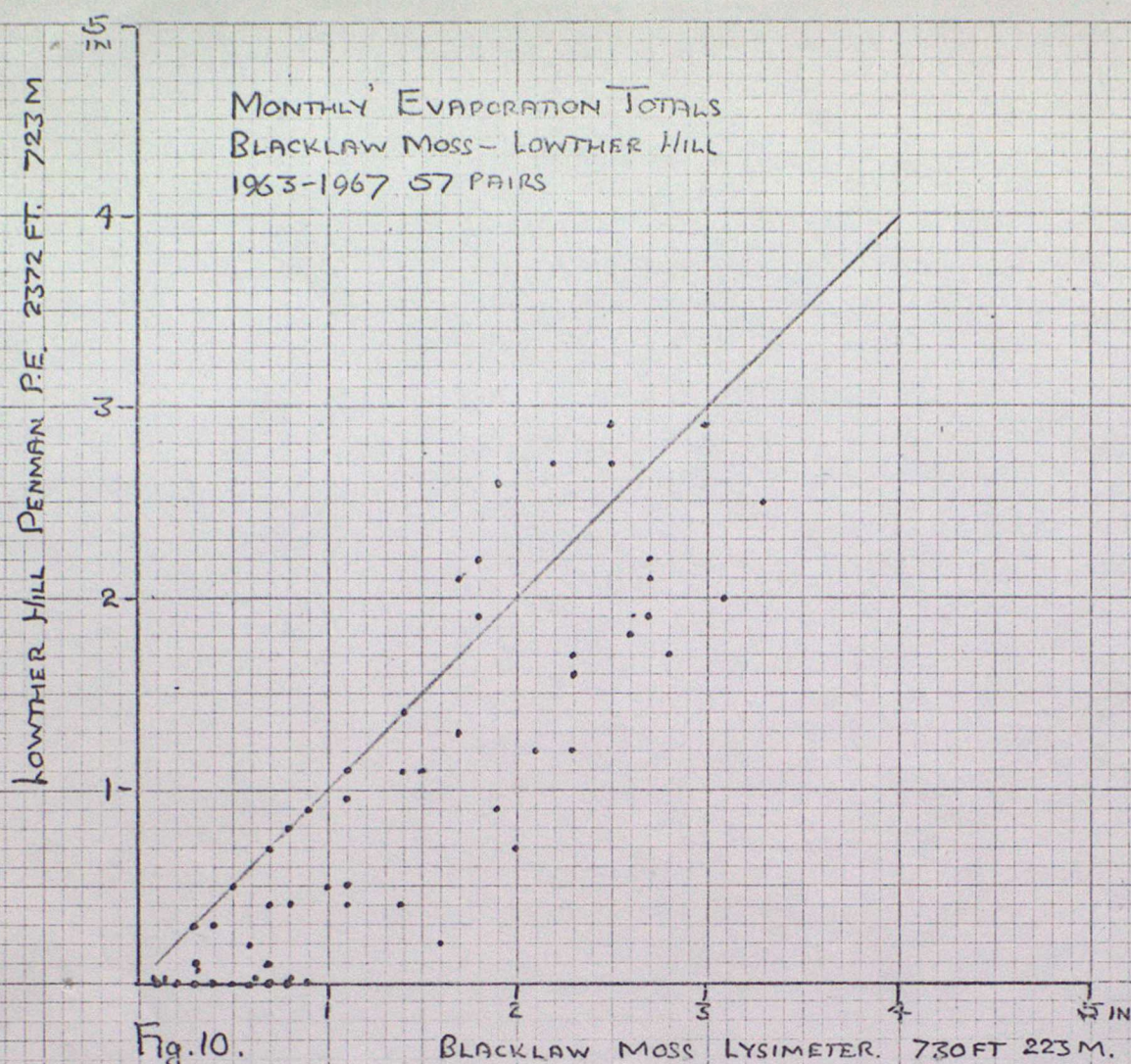








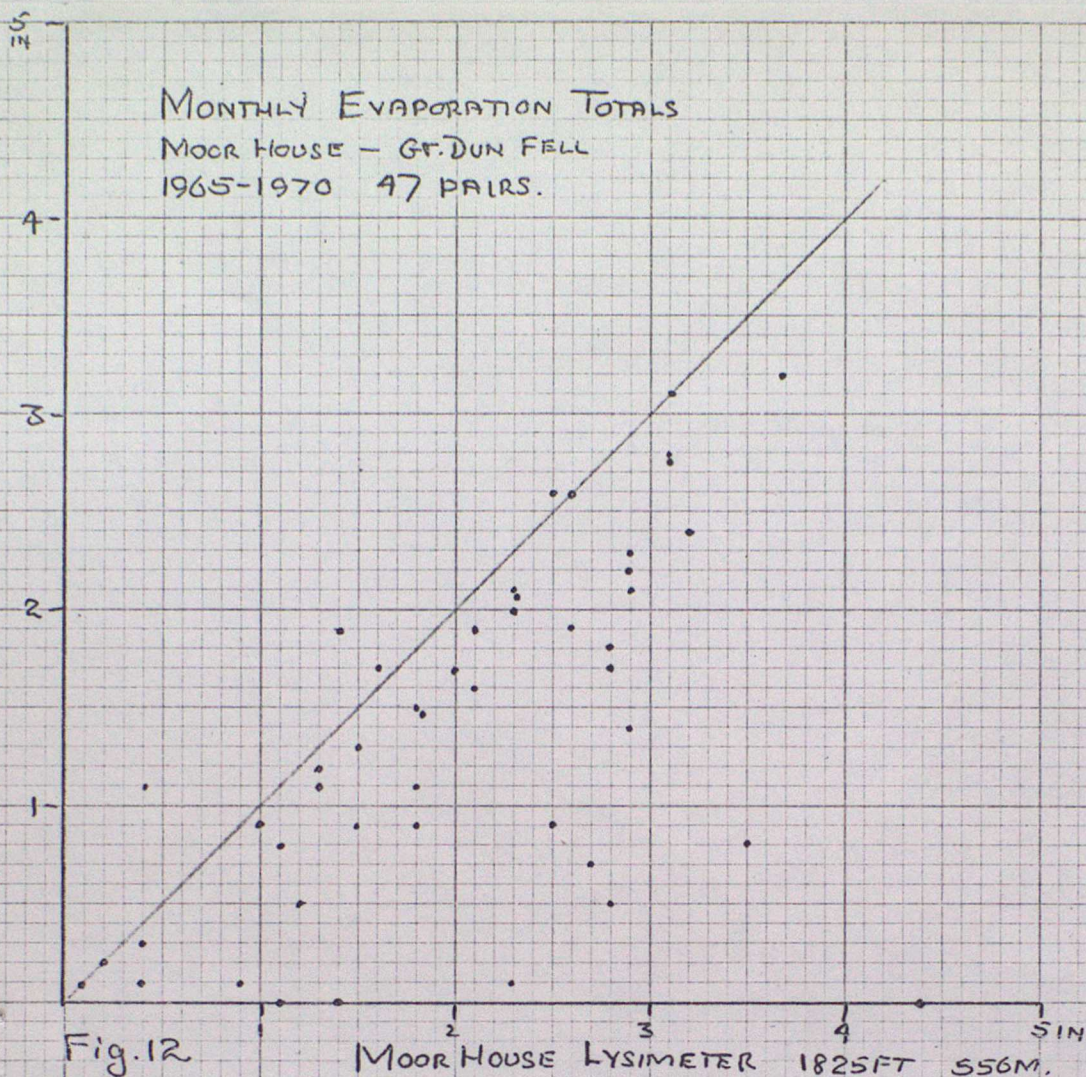




GREAT DUN FELL PENMAN P.E. 2780FT 847M.

MONTHLY EVAPORATION TOTALS

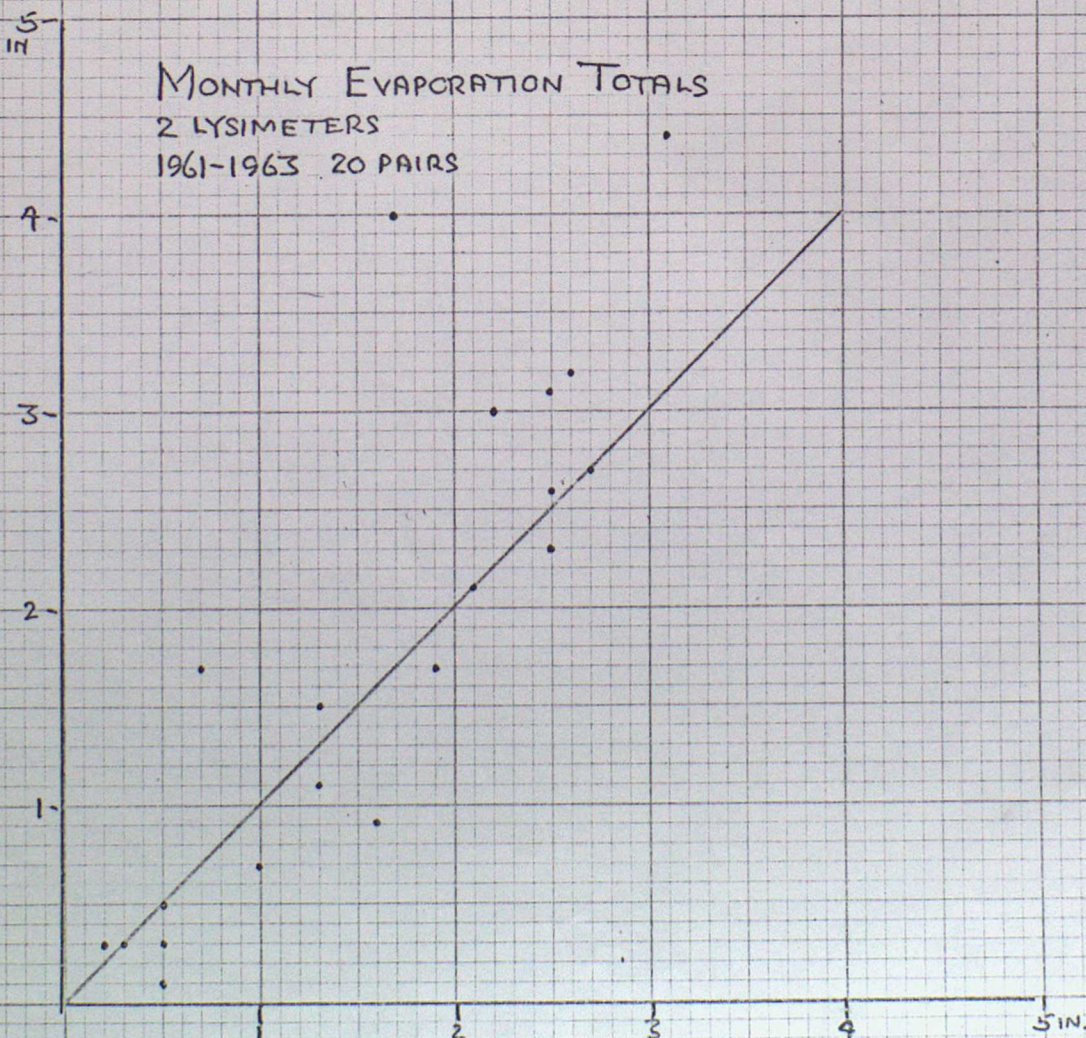
MOOR HOUSE - GF. DUN FELL
1965-1970 47 PAIRS.



WEST HOUSES 1165FT 355M.

MONTHLY EVAPORATION TOTALS

2 LYSIMETERS
1961-1963 20 PAIRS



SLAIDBURN 210 PENMAN P.E. 629 FT 192M.

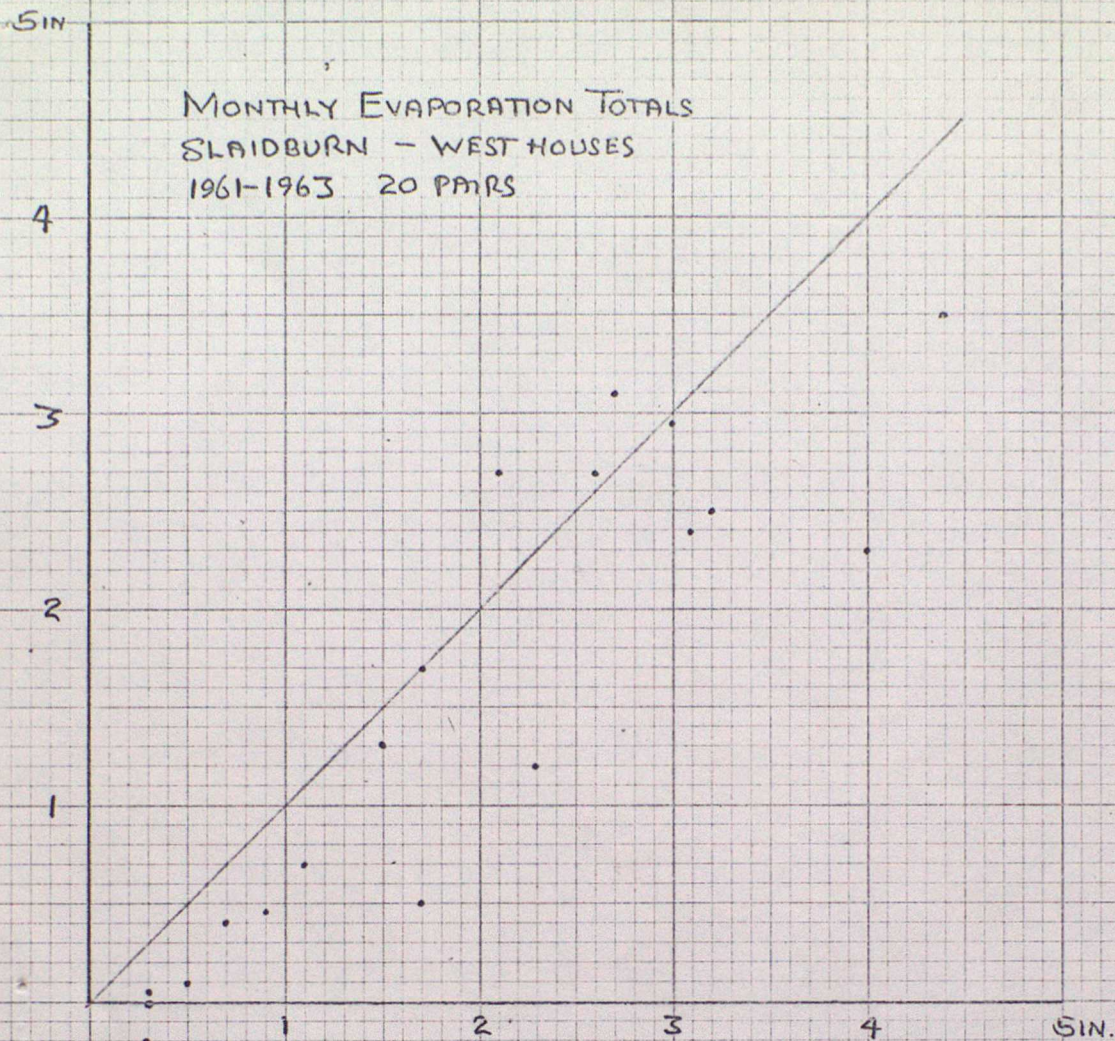


Fig. 13A.

WEST HOUSES LYSIMETER. 1165 FT 355M.

VALLEY PENMAN P.E. 32 FT 10M

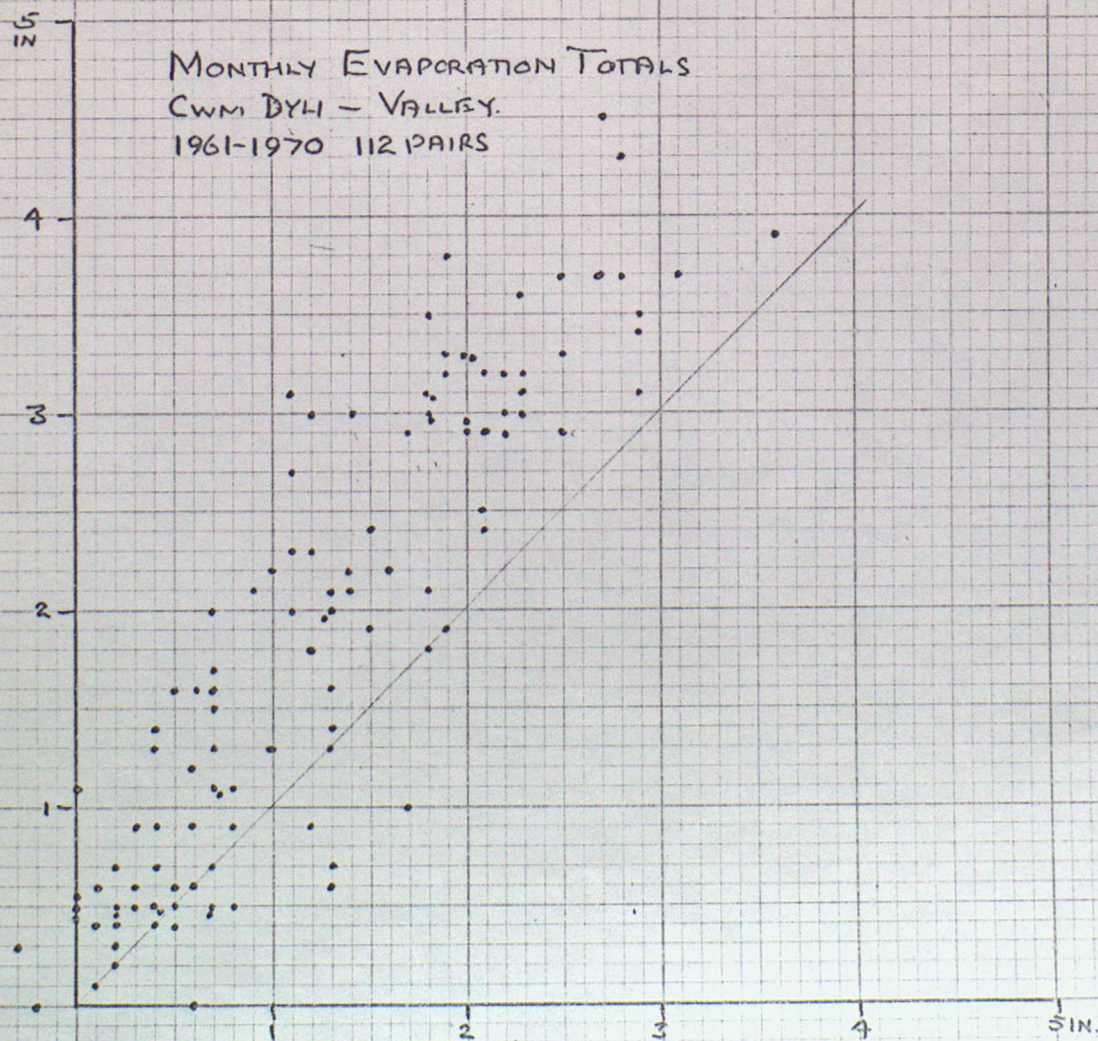


Fig. 14

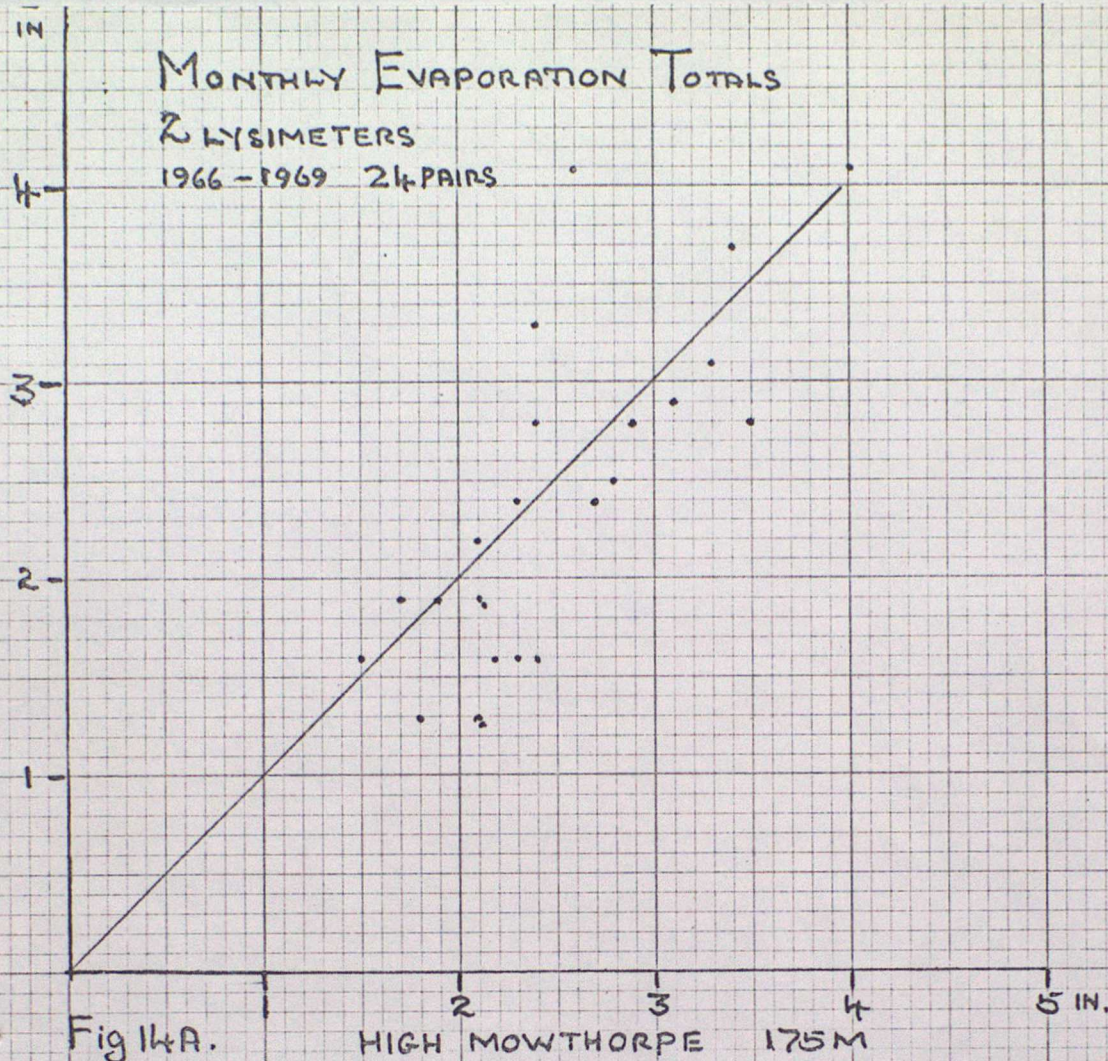
CWM DYLI LYSIMETER 310 FT 94M

WITHERNWICK (WESTLANDS FARM) 12 M. (40 FT).

MONTHLY EVAPORATION TOTALS

2 LYSIMETERS

1966-1969 24 PAIRS

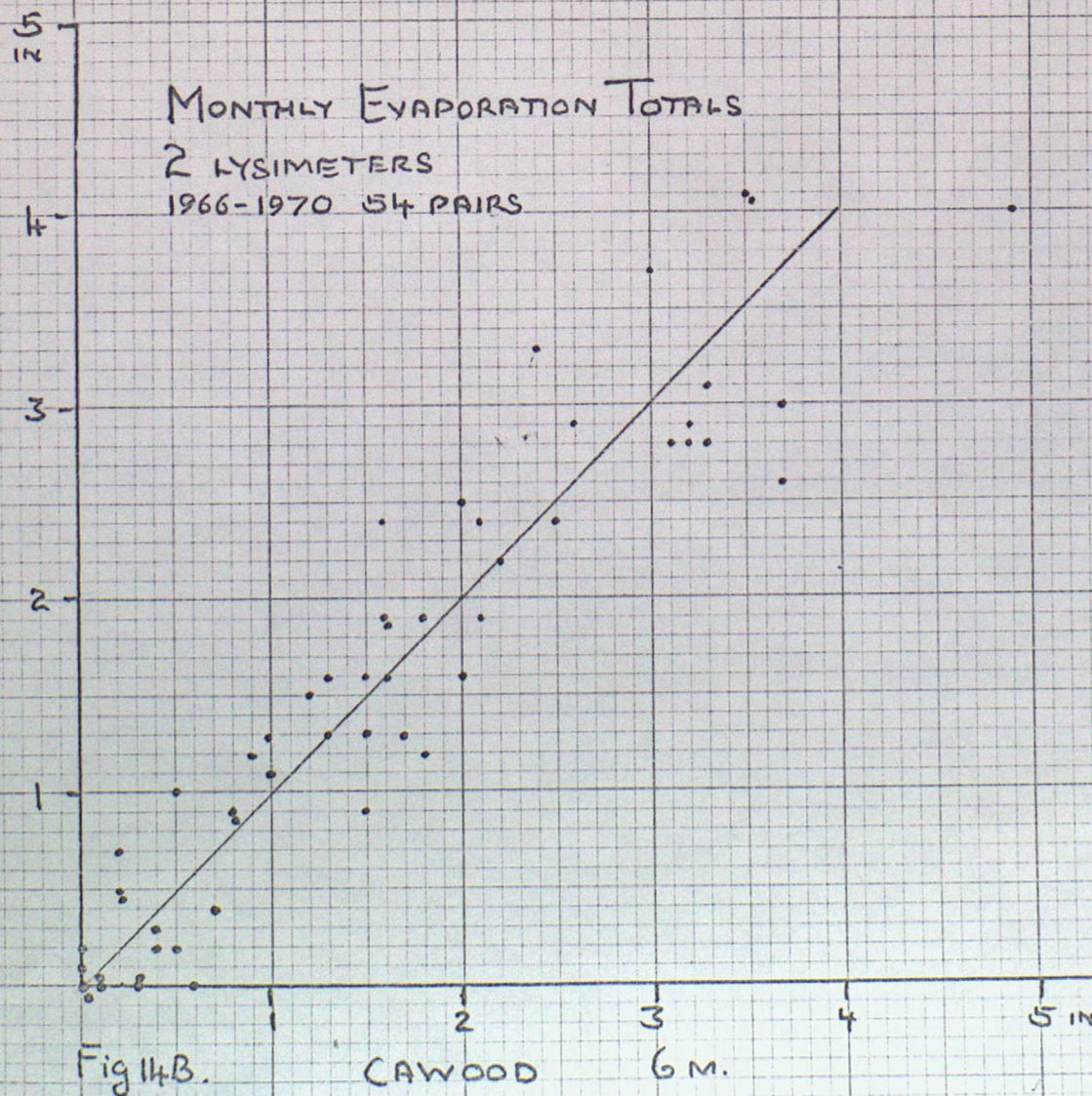


WITHERNWICK (WESTLANDS FARM) 12 M (40 FT)

MONTHLY EVAPORATION TOTALS

2 LYSIMETERS

1966-1970 54 PAIRS



SUTTON BONINGTON 157FT 48M.

20

4

3

2

1

Fig. 15

MONTHLY EVAPORATION TOTALS
2 LYSIMETERS
1965-1970 66 PAIRS

MOUNT ST. BERNARD 600FT 183M.

5 IN

SUTTON BONINGTON PENMAN P.E. 157FT 48M.

5 IN

4

3

2

1

Fig. 15A

MONTHLY EVAPORATION TOTALS
SUTTON BONINGTON - MOUNT ST. BERNARDS.
1965-1970 66 PAIRS.

MOUNT ST. BERNARD 600FT 183M.

5 IN

WOOD WALTON FEN. 5FT 2M.

INS.
4

MONTHLY EVAPORATION TOTALS
2 LYSIMETERS
51 PAIRS

3

2

1

Fig.16.

MONKS WOOD 125FT. 38M.

4 INS

WYTON PENMAN P.E. 141FT 43M.

INS.
5

MONTHLY EVAPORATION TOTALS
MONKS WOOD - WYTON

1963-1970 79 PAIRS

4

3

2

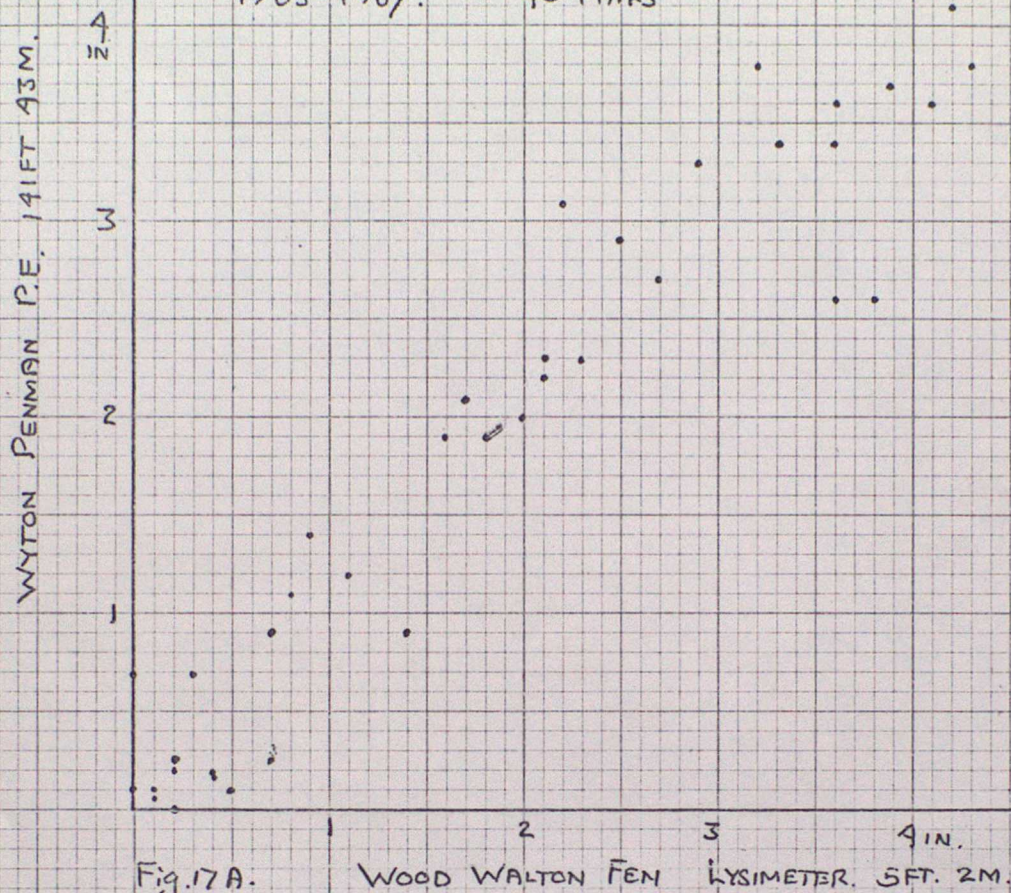
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Fig.17.

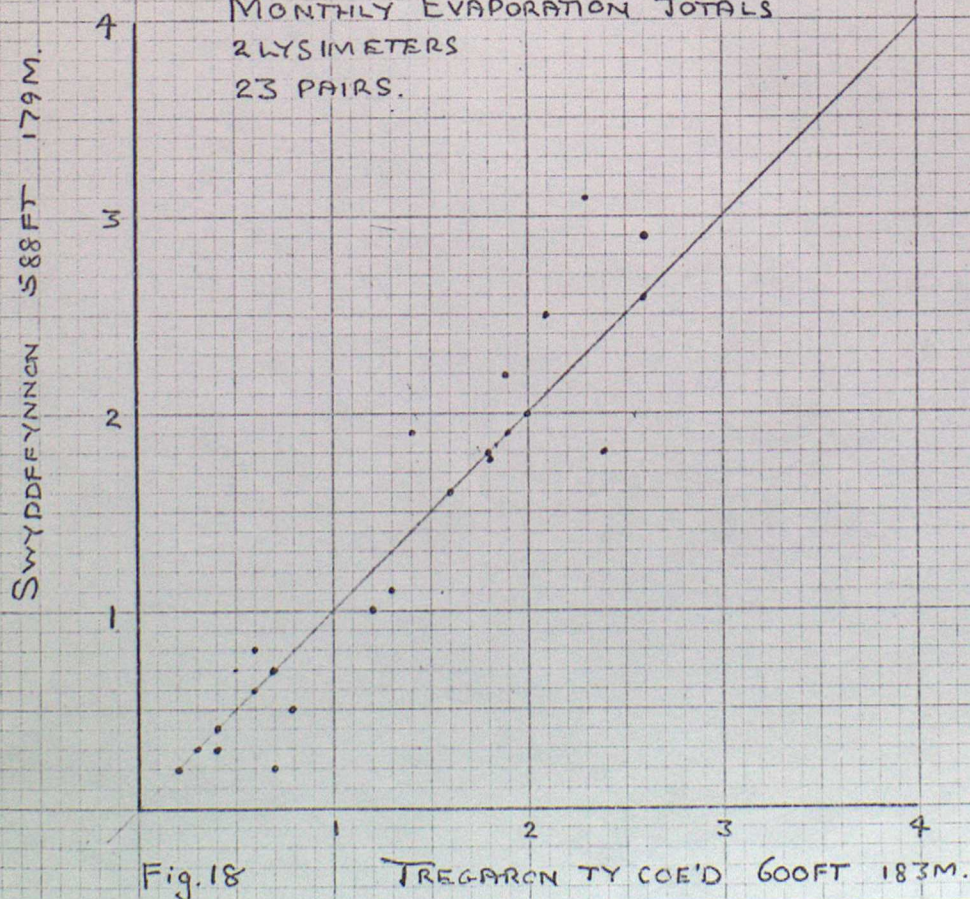
MONKS WOOD LYSIMETER 125FT 38M

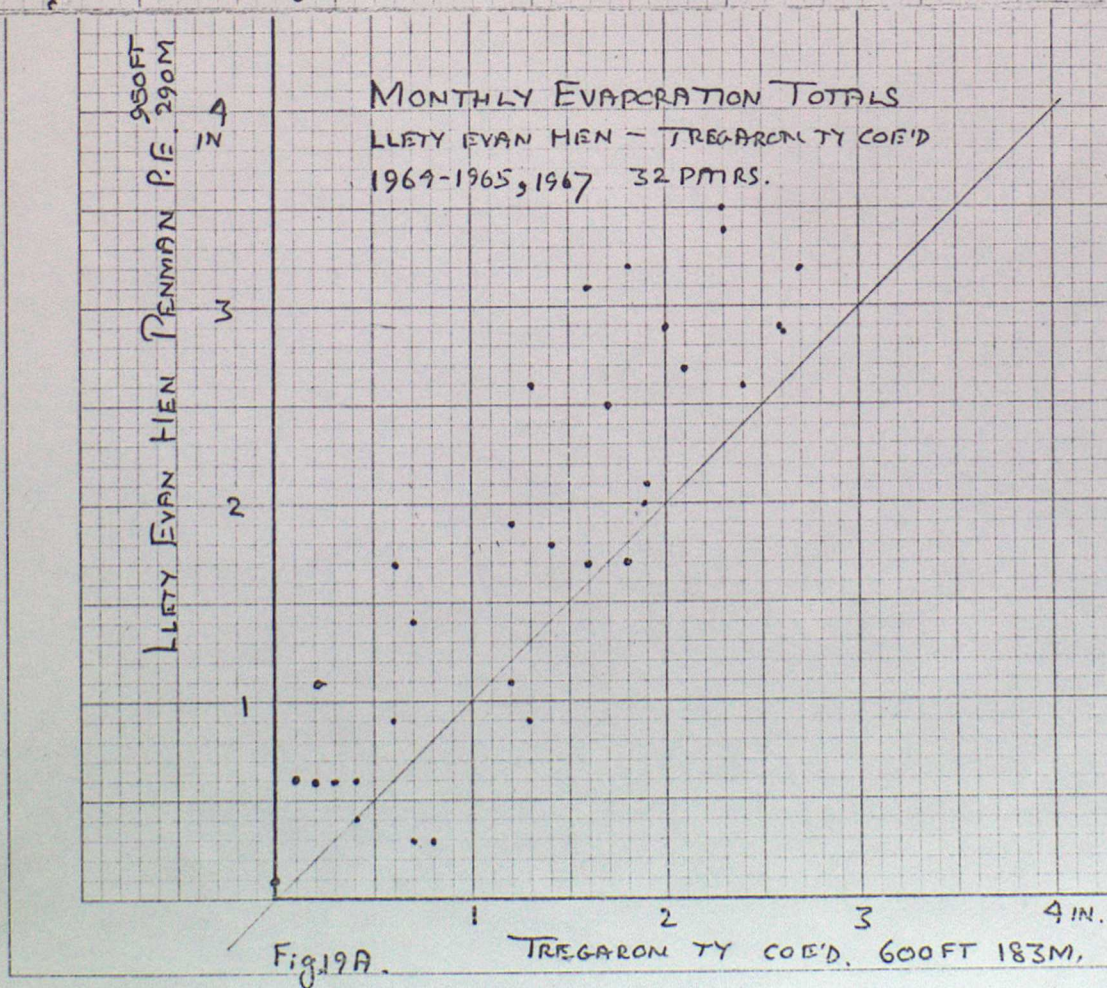
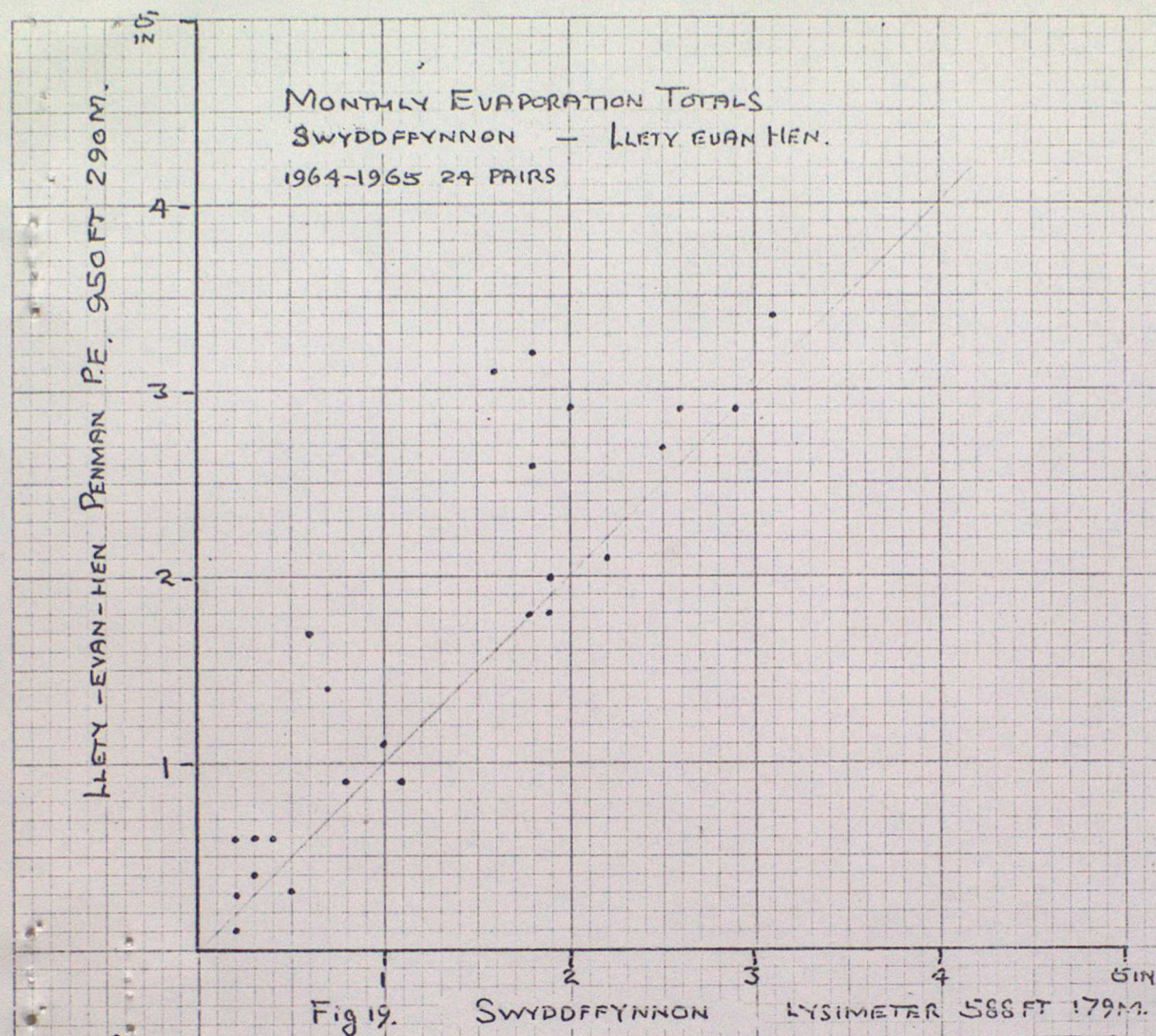
5 IN

MONTHLY EVAPORATION TOTALS
WYTON - WOOD WALTON FEN.
1963-1967. 40 PAIRS



MONTHLY EVAPORATION TOTALS
2 LYSIMETERS
23 PAIRS.





GRENDON UNDERWOOD 220 FT. 67M.

5
INS

MONTHLY EVAPORATION TOTALS
2 LYSIMETERS
1969-1970 21 PAIRS

4
3
2
1

Fig. 20.

WALLINGFORD 157 FT 48M.

5 INS

ABINGDON PENMAN P.E. 210 FT 64M.

5
INS

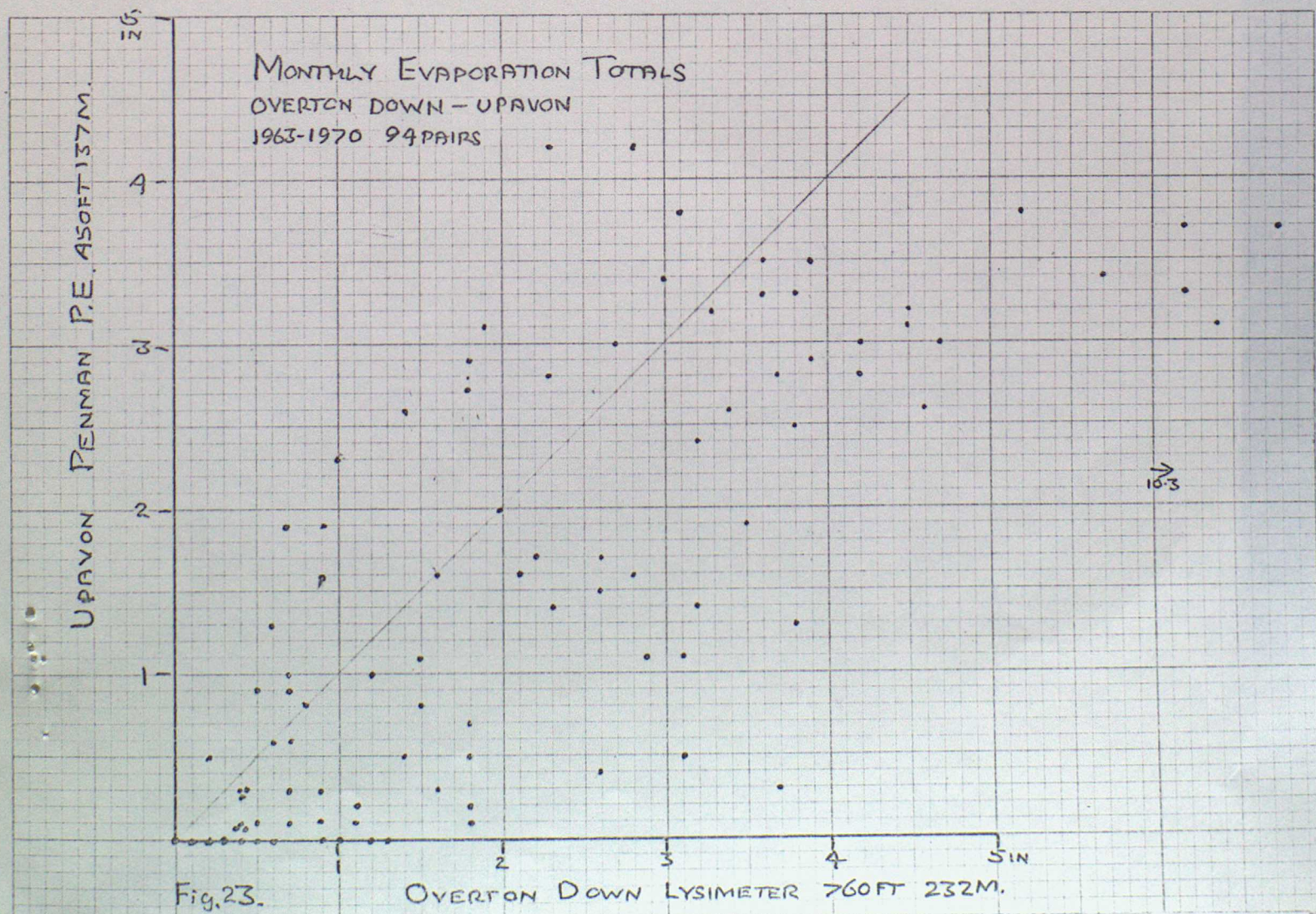
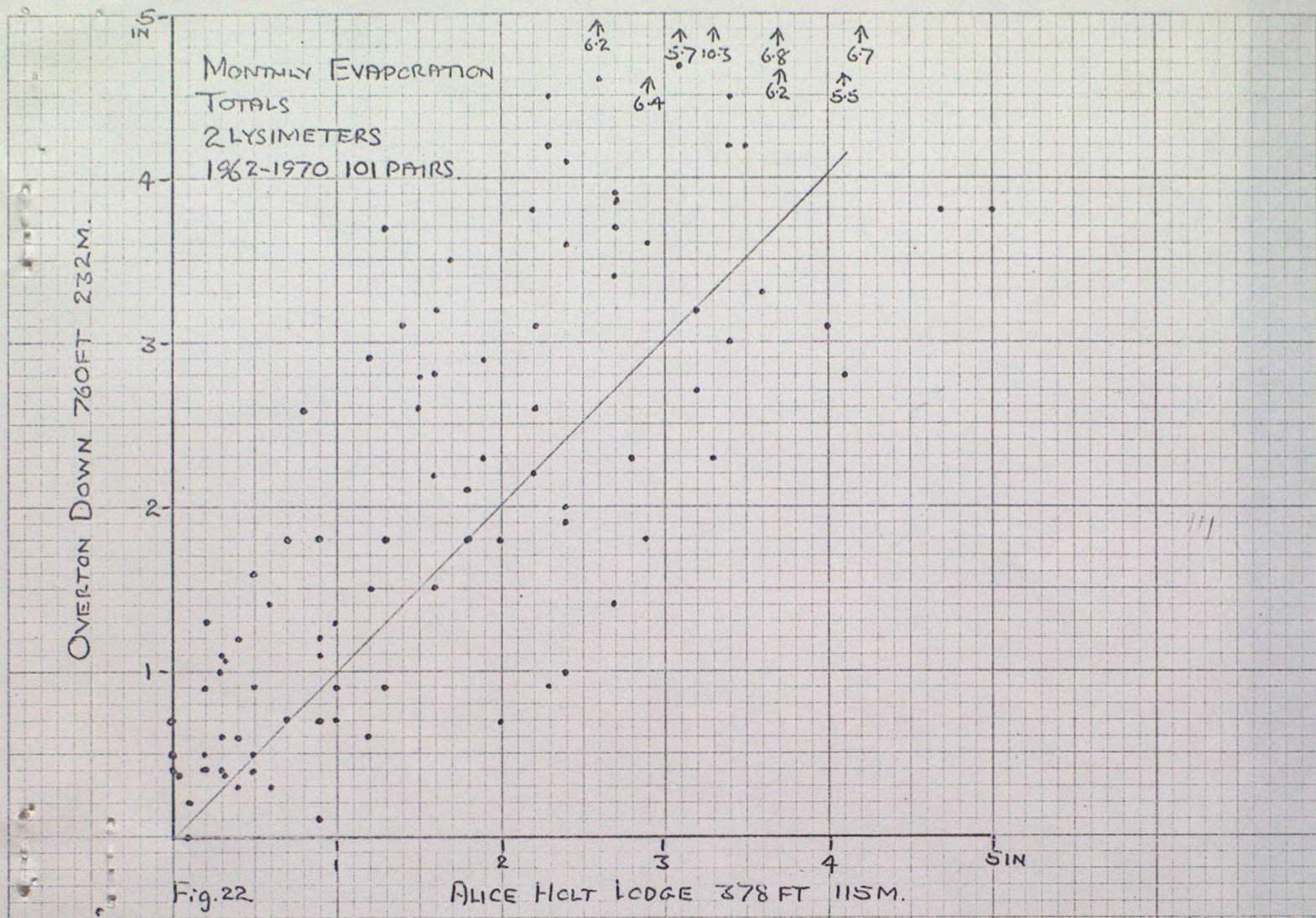
MONTHLY EVAPORATION TOTALS
1968-1970 27 PAIRS
GRENDON UNDERWOOD - ABINGDON

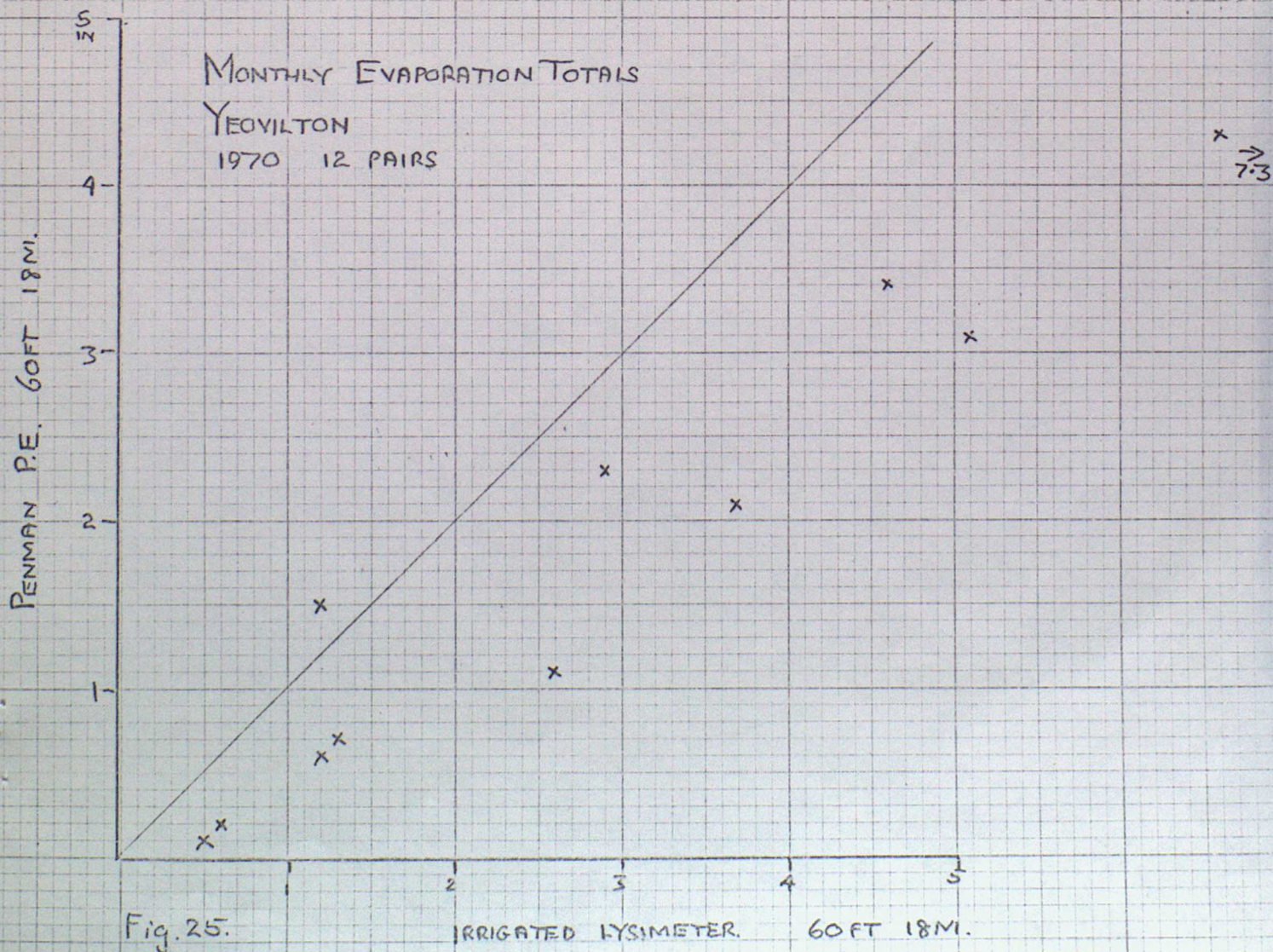
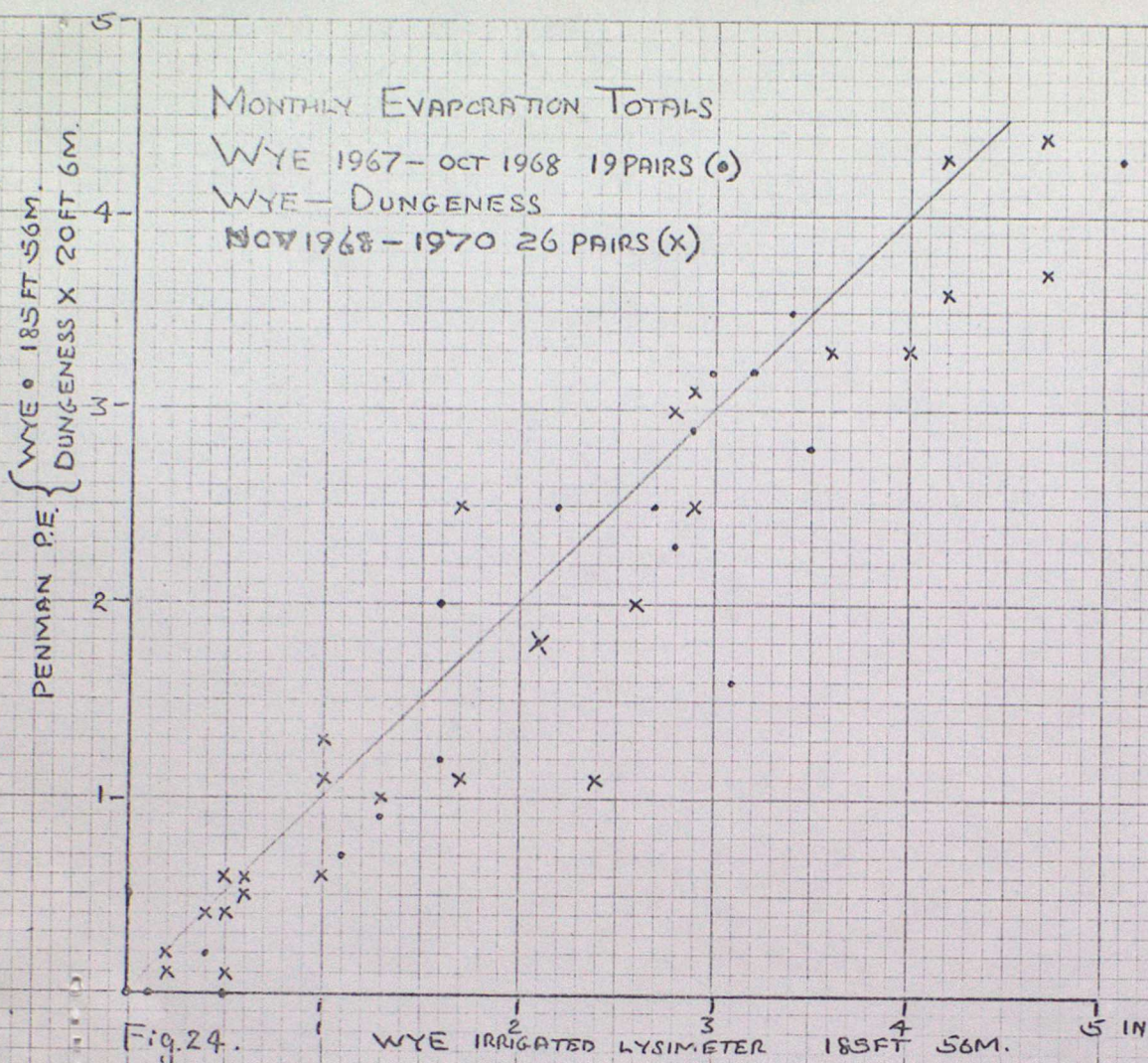
4
3
2
1

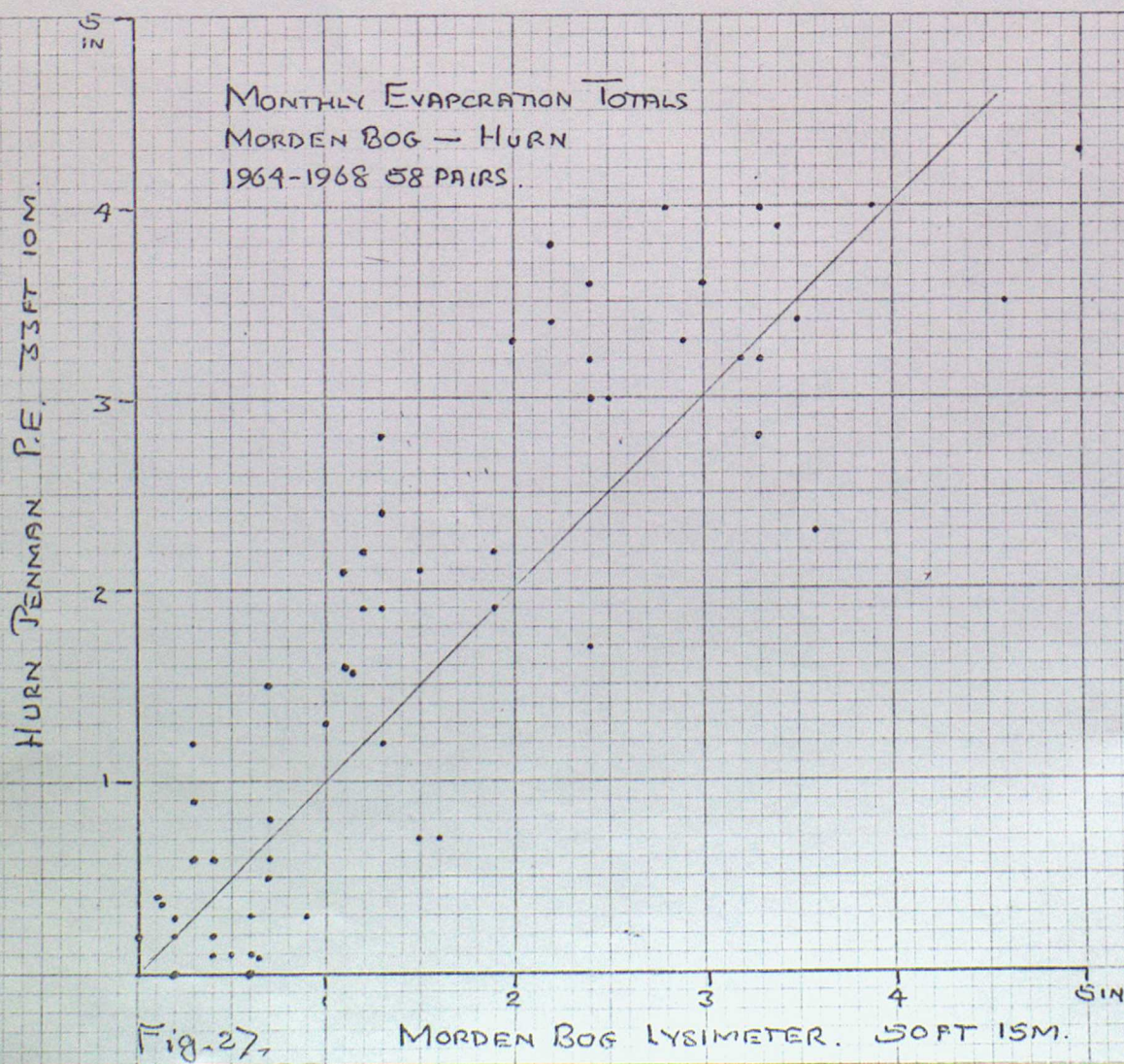
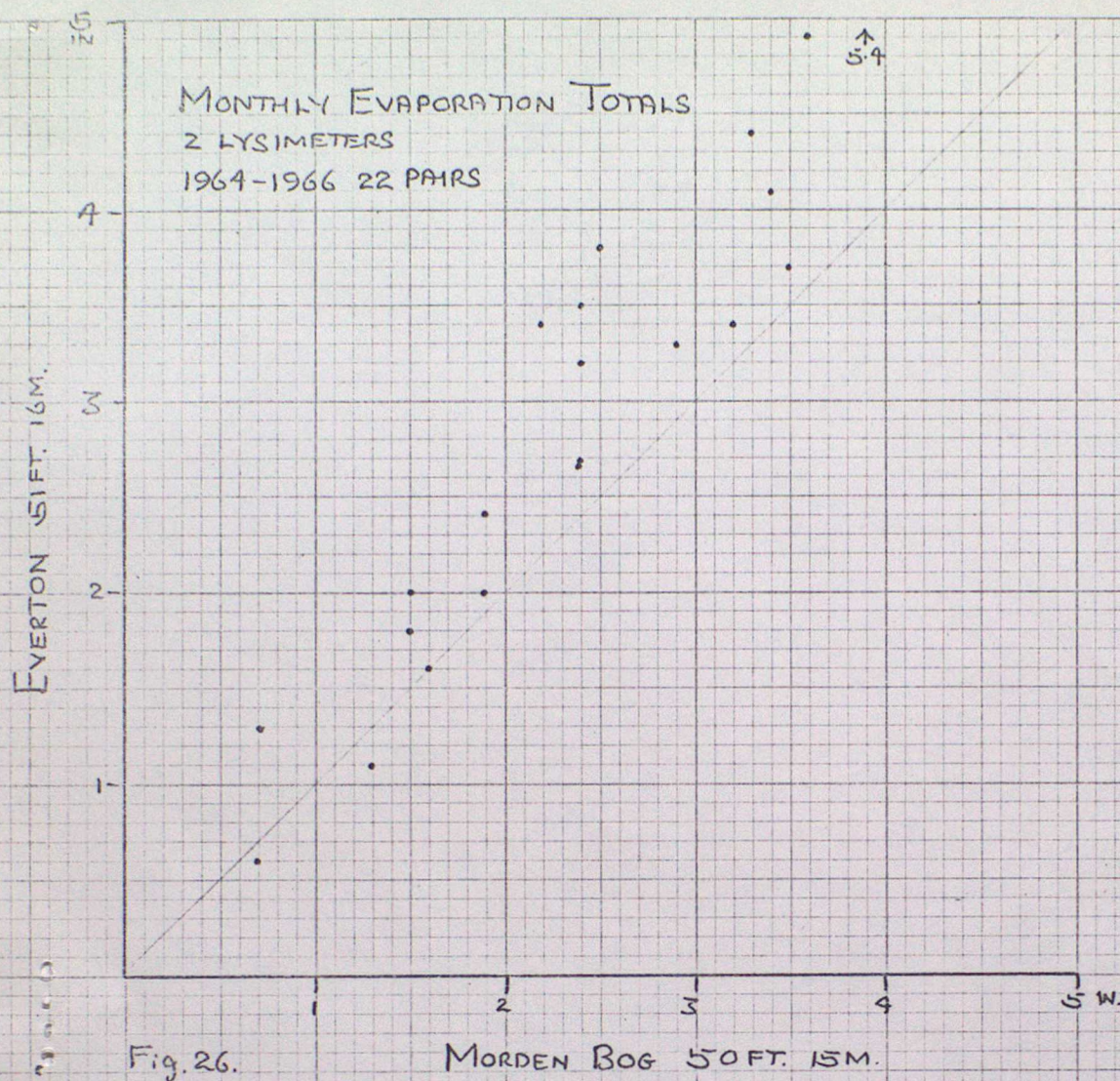
Fig. 21.

GRENDON UNDERWOOD LYSIMETER 220 FT 67M.

5 IN







PENMAN P.E. 600FT 183M.

MONTHLY EVAPORATION TOTALS
YARNER WOOD
1967-1968 19 TOTALS

Fig. 28.

IRRIGATED LYSIMETER 600FT 183M.

ROSEWARNE PENMAN P.E. 249FT. 76M.

MONTHLY EVAPORATION TOTALS
CULDROSE - ROSEWARNE
1970 12 PAIRS.

Fig. 29.

CULDROSE LYSIMETER. 269FT. 82M.