THE STATUS AND AUTECOLOGY OF *DOLOMEDES PLANTARIUS* ON LOPHAM AND REDGRAVE FEN NATURE RESERVE IN 1992

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SUMMARY

In 1992 the numbers of *D. plantarius* on both the Middle and Little Fens of Lopham and Redgrave Fen NR were very similar to those recorded in 1991. They remained precariously low. Population estimates were derived from maximum counts within defined periods. Biases in this method of estimation are discussed.

Forty-five females were seen carrying egg sacs during the season but the number of breeding females was likely to have been lower than this because some individuals attempted to breed twice. Only twenty-four nursery webs were found and most appeared to have failed, possibly because of avian predation. Females were seen with egg sacs from late May to the end of September but the proportion that were subsequently found with webs declined in August and September. Late breeding attempts were often second broods. They were more likely to fail because the females were in poorer condition and the weather was less favourable than at the peak of the season. Breeding success was higher on Little Fen than on Middle Fen, where much lower water levels in July and August resulted in a lack of suitable emergent vegetation for web-construction.

In 1991 the water levels on both fens were much lower than in 1992 and no webs were seen during an equivalent survey. Very small numbers of half-grown immatures emerged from hibernation in 1992, further indicating poor breeding success in the middle of the 1991 season, when this size class would have been produced. However, the numbers of small immatures emerging at the beginning of the 1992 season was relatively large, suggesting that late-season breeding attempts were probably more successful in the warmer autumn of 1991, than in 1992.

The distribution of spiders between pools was extremely patchy but we remain largely ignorant of the factors that determine their distribution. Although numbers correlated significantly with mean water levels, this factor explained little of the variability.

The pools occupied by the core of the population in 1992 were irrigated by a piped water supply from 2 June until the end of November. On Little Fen this maintained water levels at or slightly above the level in early April but on Middle Fen irrigation was insufficient to prevent a substantial fall in levels in late July and August. To prevent excessive shading in and around the pools the vegetation around the margins was cut in late April and emergent vegetation within the pools was carefully cut and removed in late June.

The existing monitoring scheme would measure any further decline or loss of spiders from their last two centres of population on the Fen but does not provide an adequate baseline for monitoring their recovery, should such occur. Recommendations are made for modifying the monitoring scheme to include a wider area of the fen so that any spread of the population can be detected. Recommendations are also given for improving the scientific basis of management work and for assessing the success of management.

1 INTRODUCTION

In this report I describe the results of a survey of the status of *Dolomedes plantarius* on Lopham and Redgrave Fen Nature Reserve, in 1992. The work was funded by English Nature's Rare Species Recovery Programme. I cover the work undertaken by Dr. Eric Duffey between 30 April and 28 May and continued by myself between June and October. In addition to the survey data, volunteers collected additional, more frequent observations of spiders in one of the two survey areas. I have used these data where they contribute to our understanding of the population dynamics and life histories of *D. plantarius*. I also describe habitat management work undertaken in 1992 to prevent the pools occupied by the spiders becoming choked by vegetation. This work was also funded by the Rare Species Recovery Programme.

The population of *D. plantarius* on Lopham and Redgrave Fen NR is one of only two in Great Britain (Kirby 1990). The species is internationally rare and its presence on the Fen was an important factor in the reserve's designation as a RAMSAR site in 1991. In addition to the extreme national rarity of this species, its population on the Fen has become endangered. The history of its population on this site since its discovery in 1956 is comprehensively described by Duffey (1991) and I summarise it here only briefly. Drastic loss of water from the Fen followed the installation of a borehole adjacent to the reserve in 1960. This loss was compounded by three years of drought from 1989 onwards. The mean water table on the fen in driest parts of summer in 1990 and 1991 was around 70 cm lower than in 1985. Many of the pools formerly occupied by the spiders dried out and became overgrown.

By the early 1980's spiders were restricted to three areas of the Fen (Thornhill 1985). On Little and Middle Fens these areas were extensive although on Redgrave Fen it occupied less than half a hectare. The Middle and Little Fen populations were separated by *ca* 0.75 km and it is extremely unlikely that there has been any interchange between them since this period. By 1991 *D. plantarius* had been lost from Redgrave Fen and its range had contracted to pools in two small areas on Little and Middle Fens. Most of the occupied pools on Middle Fen were machine-dug in 1986 and those on Little Fen were dug in 1989: few of the older pools on the fen, most of which originated as peat diggings, were sufficiently deep to hold water. By July 1991 the water levels in many of the newer pools were also very low. They were almost certainly prevented from drying-out completely by the installation, by the Suffolk Water Company, of irrigation pipes which fed 13000 litres hour^{-1} of de-chlorinated water to the pools in the core areas of the populations on Little and Middle Fens. Irrigation began on 2 August in 1991 and on 2 June in 1992. It was discontinued in late autumn when the water table had risen sufficiently to maintain levels in the pools.

English Nature's Rare Species Recovery Programme first funded monitoring of these two remaining centres of population in 1991. The primary aim of the monitoring scheme was to estimate the size and age-structure of the core of the remaining population (Duffey 1991). Regular measurement of the water levels in the pools was also undertaken. By August 1991 the Fen was so dry that few pools other than those irrigated and monitored contained water. At that time is was likely that the estimates of numbers of spiders approximated to the greater part of the population. The 1992 survey addressed the same primary aim of estimating the size and composition of the population in the two areas. This methodology was similar although, for much of the season, the sampling frequency was lower. To compensate for this lower sampling frequency and to increase understanding of the phenology and breeding biology of the population, the systematic survey was supplemented by casual recording by volunteers. This information is essential if management operation are to be properly timed to minimise damage to the animals.

In this report I describe the details of the survey methods, and then present and discuss results on the size and structure (by age and sex) of the populations, on breeding success and on breeding biology. I also describe the changes in water levels and the management operations on the pools and discuss, as far as possible, the effects of these factors on the spiders. In each section I compare the results for Little and Middle Fens. In the final conclusions and recommendations I concentrate on re-evaluating the aims of the programme in the light of two years' of data collection, and make proposals which would fulfil future requirements for monitoring and management. Aspects of the data that are peripheral to the main aims of the survey, but which contribute to understanding the species ecology, are included as appendices. Summaries of the data on spider numbers and water levels for individual pools are also included as appendices to facilitate comparison with future years' data.

2 METHODS

2.1 The survey sites

We monitored the same series of pools, on Little and Middle Fens, as the 1991 survey (Figs. 2.1 and 2.2). The pools were chosen subjectively from amongst those that held water in the core areas of the spider population in 1991 (see above and Duffey 1991). In May and June, spiders were counted on exactly the same 29 pools on each fen, as in 1991. On Little Fen two of the pools were just beyond the irrigated area and on Middle Fen eight of the pools formed a separate series well away from the irrigated area. From July onwards, five additional pools were included from each fen to increase the baseline sample size for monitoring experimental management operations in future years (see Section 4.5). On Little Fen the additional pools were all within the main irrigated area but on Middle Fen two were within the irrigated area and three in the unirrigated series.

2.2 Survey methods

2.2.1 Systematic recording of spiders

All pools were monitored systematically on ten occasions during the season. The pools were monitored at the end of April and three times in May but from June onwards they were sampled only at approximately three-weekly intervals (Table 2.1)

Table 2.1 Dates of monitoring rounds in 1992

Middle Fen	Little Fen
30 April	1 May
13 May	14 May
20 May	21 May
27 May	28 May
11 June	11-12 June
26 June	26-28 June
15 July	18 July
9-10 August	12-13 August
5 September	31 August- 3 September
28 September	29-30 September

Whenever possible monitoring was restricted to warm sunny weather and all pools on each Fen were sampled in one day. However, because of poor weather in August and September, some sample rounds had to be spread over two or three days. Because the spiders appear to move between pools only infrequently, sampling in favourable weather was given priority over sampling in the shortest possible time.

After initial examination of a pool from one point on the bank, the water surface and the margins were searched thoroughly for *D. plantarius*. In May the pools were searched thoroughly by walking round both the banks and the water. The emergent marginal vegetation was moved carefully with a leaf rake, with straightened tines, to allow thorough searching of the pool edges. From June onwards the pools were searched only from the water to avoid trampling the banks. As soon as nursery webs were discovered in the emergent marginal vegetation some thoroughness of searching was sacrificed to ensure that webs were not disturbed.

Wherever possible, the following variables were recorded for each individual:
1. Sex
2. Body length in mm (for immature stages only)
3. Size/life cycle stage category. The following categories were recorded for adults and other stages where more precise body length measurement could not be made: A, adult; L, large immature; M, half-grown; S, small immature).
4. Banding pattern (banded or unbanded).
5. Band and body colour
6. Whether pregnant, carrying egg sac or attending web with young or empty web.
7. Whether the individual 'dived' (diving behaviour usually involved spiders walking a short distance under the water surface on stems or under leaves).
8. Location. A sketch map was drawn of the locations of each individual on the pool. These locations were later summarised as falling in one of four quadrants of

the pools and as at either the edge, on the open water, or on a vegetation island (e.g. emergent clumps of *Cladium mariscus*).

For analyses of the age-structure of the population, body length and life-cycle stage category data were combined to define the following categories: adult, large immature (15mm or more), half-grown immature (greater than 8 and less than 15mm) and small immature (8 mm or less). A high proportion of the large immatures were likely to have been sub-adults.

From June onwards, separate records were made of all skins (including variables 1,3,4 and 8) and of all nursery webs. The presence or absence of young, height in the vegetation, species composition of the vegetation and location of each web was recorded.

2.2.2 Casual recording of spiders

Casual records were made on the pools on Little Fen only. They comprised collection of exactly the same variables for each individual, skin or web as in the systematic surveys but the pools were searched only from one point on the bank and at variable intervals. These records were used primarily to provide more detailed information on the phenology of breeding than could be obtained from the three-weekly monitoring rounds. The data were also used to supplement population estimates for individual pools from June onwards, when the frequency of systematic sampling was low and the probability of failing to record individuals was consequently relatively high. Because casual recording was confined to Little Fen, estimates that include casual records have not been used for comparisons of the size of populations on Little and Middle Fen.

2.2.3 Water levels

At each sample round the water level in each of the original series of 29 pools was recorded. In early April oak posts were driven into the sediments in each pool at the same point as the bamboo canes used for this purpose in 1991 (Duffey 1991). The tops of the posts were levelled 30 cm above the water surface on Middle Fen and 40 cm above the water surface on Little Fen. Water level was recorded to the nearest 0.5 cm, as the distance from the top of the post to the water surface. It was later computed as the difference between the April datum and the level recorded on each subsequent date.

2.2.4 Data analysis

All data were computerised as an ASCII file and subsequently summarised and analyzed using the SAS statistical package (SAS Institute 1988).

It was often possible to identify individual spiders on successive sampling occasions, particularly when periods of only a few days elapsed between inspection of the pools for casual records. Where individuals were re-recorded with reasonable confidence, they were assigned an identity number. I attempted to do this for as many adult females and their webs as possible on Little Fen. These numbers enabled us to assess more accurately the numbers of females present and to make rough estimates of the duration of pregnancy, of egg sac carrying and of young in the nursery webs.

3 RESULTS AND DISCUSSION

3.1 Overall population size

The numbers of spiders on the series of 29 pools on both Little Fen and Middle Fen were similar in 1991 and 1992 (Table 3.1). Adult numbers were higher on Little Fen than on Middle Fen in both years and numbers of adult females were slightly higher on both fens in 1992 than in 1991. Numbers of immatures were very similar on Middle Fen in both years but on Little Fen they were substantially higher in 1992 than in 1991. — Effect of irrigation?

The 1992 population estimates in Table 3.1 were obtained by the same method, and with the same subdivisions by age and sex, as used by Duffey for the 1991 data (Duffey 1991). They were calculated as the sums of the maximum number of male and female adults, and of all immatures, recorded on each pool at any date during the season. Population estimates made by this method are likely to increase with the sampling frequency because the probability of encountering extreme values increases. Since the pools were monitored at weekly intervals in 1991 but only at *ca*. three-weekly intervals during much of 1992, this is likely to have resulted in a relative underestimation of the 1992 population. To compensate partially for the lower sampling frequency in 1992, a second population estimate was made which included both casual records and records of skins, where the numbers of fresh skins exceeded the numbers of individuals found (numbers in parentheses in Table 3.1). However, inclusion of casual records is likely to lead to relatively higher estimates for Little Fen than for Middle Fen (see Section 2.2.2).

A second source of bias in this method of estimating population size arises from the inherent assumption that spiders do not move between pools. If movement occurred it would lead to overestimation of the population. Kennett's (1985) estimate, using marked individuals, of 5% of individuals moving between pools, suggests that this bias is likely to be relatively small and there is no reason to assume that it would have differed between 1991 and 1992. It may, however, be greater in years when the fen is wetter.

Table 3.1 Numbers of *D. plantarius* in 1991 and 1992

Year	Little Fen			Middle Fen		
	Adult males	Adult females	Imms.	Adult males	Adults females	Imms.
1991	14	15	24	6	6	62
1992	4 (5)	19 (23)	67 (85)	6 (6)	10 (11)	65 (67)

Note: numbers in parentheses include records of skins and casual records (see text). Data are sums of maximum counts from the same 29 pools in each year.

The difference in sampling frequencies between 1991 and 1992 makes it impossible to evaluate the statistical significance of the higher numbers of adult females on both fens, and of immatures on Little Fen, in 1992. However, since these population estimates increased while the sampling frequency decreased, it seems likely that they represent real increases. Detailed breakdown of the 1991 data by age and sex classes were not available for the preparation of this report but comparison of the numbers of large immature females at the end of the 1991 season with the numbers of adult females emerging early in 1992 may give a better estimate of the comparability of the two years' data. It is also impossible to assess from these data whether the higher numbers of immatures recorded on Little Fen in 1992 resulted from improved breeding success in late 1991 (the individuals were therefore unlikely to have been counted in 1991) or in 1992. This problem is addressed in Section 3.2 below by breakdown of the data by month and by additional size classes. Better comparison of the relative breeding success in 1991 and 1992 will also be possible when this breakdown is available for both years.

Irrespective of the biases discussed above in the method of estimating population size from the count data, these figures are likely to underestimate the real population size because of failure to find some individuals. Individuals may have been missed on pools which were recorded and others will have been missed on pools which were not recorded. At present we have no means of assessing the proportion of the population sampled by this census. In July and August 1991 few other pools were thought to hold water and so the greater part of the population may have been on the monitored pools at this time. In 1992 counts on five additional pools within each main series from July onwards (see 2.2.1) increased the numbers cited in Table 3.1 by two adults females and nine immatures on Little Fen and by one adult female and 15 immature on Middle Fen. Spiders and webs were also observed at pools away from the main series.

The implications for conservation of this species of censusing an unknown proportion of the population are discussed further in Section 4.2. Underestimation of the true population size is not a problem if only a relative index of the size of the population is required. However, the reliability of such an index depends on the magnitude of any biases in the probability of recording the categories that are compared. In 1992 several such biases seemed likely, in addition to the problem of differing sampling frequencies between years (above). The detection probability of spiders in Middle Fen was thought to have been lower than in Little Fen because the area of shallow water under dense *C. mariscus* around the pools was much greater. This was difficult to search efficiently. The detection probability was likely to have increased as the water level fell but decreased in August when much of the mixed marginal vegetation lodged into the water. Individuals were more difficult to detect in pools with dense floating vegetation, such as *Juncus subnodulosus* and *Potomogeton natans*. Individuals may also be missed because they dived but the 1992 data show that the probability of individuals diving was similar in all age classes except in juveniles less than 8mm, which were never seen diving (adults

10%, large immatures 15%, half-grown 14%). The impact of these biases on the results cannot be assessed without proper validation of the counting method (see Section 4(2)).

3.2 Relative abundance of different size/age classes during 1992

The changes in the numbers of spiders in different age classes (adults and large, half grown and small immatures) during the season are shown in Figs. 3.1 and 3.2 for Little and Middle Fens respectively. Figures 3.3 and 3.4 show the data for adults and large immatures further subdivided by sex. These data were obtained by calculating the sum of the maximum numbers in each class, recorded on each pool, during each monthly period. It should be noted that these sums are always smaller than the annual maximum counts (Table 3.1) because they are derived from smaller samples. The data for each month should be roughly comparable although months with the most counts are likely to return the highest estimates. The single counts made in July and April are thus likely to lead to relative underestimates.

The total numbers, and those of all size/age classes, increased between the end of April and May (Figs.3.1 and 3.2). Part of this increase is likely to have been due to the increased sample size in May (above) and part to lower numbers on the pools early in the season. At the beginning of the season all spiders emerging from hibernation were immatures. There is no evidence from these data, or from other studies of this species, that any individuals overwinter as adults.

The small immature spiders seen in May and June must have hatched late in 1991. Their numbers declined in June as they were recruited into the half-grown size class (Figs.3.1 & 3.2). On Little Fen small immatures were seen all through the summer and it is likely that those seen from July onwards were the 1992 progeny. This size class was absent from Middle Fen in July and August, with numbers increasing again in September. This suggests that breeding in the peak of the season was less successful on Middle than on Little Fen (see also 3.2.2 below), although the smaller sample size on Middle Fen would also bias the data in this direction (see above). At the beginning of the 1991 season Duffey (1991) recorded only adults and sub-adults emerging from hibernation. The lack of smaller immatures suggests that breeding success in mid and late 1990 was lower than in either 1991 or 1992.

Very few of the spiders emerging from hibernation were half-grown (Figs. 3.1 & 3.2). This size class would have been produced in the peak of the 1991 season and its small size suggests that mid-season breeding attempts in 1991 were relatively unsuccessful. On Little Fen this size class was augmented progressively during the summer, first by recruitment from the relatively larger class of small immatures that emerged from hibernation, and later by recruitment from the cohort produced early in 1992. On Middle Fen the imbalance between the size and periodicity of the small and half-grown classes suggests that the sampling was inefficient. On both Fens, in contrast to the pattern when they emerged from hibernation, the numbers of half-grown individuals entering the winter were greater than those of small immatures. This is further evidence that mid-season breeding attempts in 1991 were less successful than those in 1992.

The large immatures that emerged from hibernation, most of which were sub-adult, were likely to have been the progeny of relatively early breeding attempts in 1991. The relative numbers of male and female large-immatures and adults are shown in Figs. 3.3 and 3.4 for Little and Middle Fens respectively. Not all large immatures were sexed but there is unlikely to have been any bias in the proportions of males and females that were unsexed. The sex ratio amongst large immatures was approximately 50:50 throughout the season; numbers of both sexes declined to very low levels in June and July, as they matured into adults. This size class was increased substantially again in August and September, almost certainly by recruitment of the spiders which overwintered as small immatures. Large immatures were much the most numerous size class entering hibernation.

Adults started to emerge during May and the numbers of large immatures declined in proportion. Adult numbers peaked in June on Little Fen but in May on Middle Fen. The relative numbers of female and male adults exhibited very different patterns (Figs. 3.3 and 3.4). On Little Fen adult female numbers peaked in June and July. Numbers in August and September were rather lower, suggesting some mortality. In contrast, numbers of adult males peaked in May and declined thereafter. No adult males were seen on Little Fen from July onwards. They appear to die after mating, early in the season. The pattern on Middle Fen differed in detail, although elements of this could be attributable to the lower sampling intensity (there were no casual records). Adult female numbers did not peak until July and then declined rapidly. The later peak is likely to have resulted from females initially being more widely dispersed amongst the dense vegetation around the flooded pool margins early in the season. As the water levels fell, females would have had to move onto the more central areas of the pools, where they were more likely to have been counted. The decline in numbers after July may have been attributable to the lack of suitable breeding sites around the pools, discussed in 3.3.2 below.

3.3 Breeding status

In this section I consider the numbers of females that attempted to breed and the success of the these breeding attempts. Data on aspects of their breeding biology that are not covered under these topics are presented in Section 3.3.3.

3.3.1 Breeding attempts

A total of 45 individual females carrying egg sacs was recorded during the 1992 season. This estimate is based on all pools and used identity numbers to distinguish different individuals from successive records of the same individual (see Section 2.2.4). Females with egg sacs were found from late May (first record on 27 May) until the last sample round at the end of September (last record on 29 September, Fig. 3.5). None were seen in October but no thorough searches were made. Numbers peaked in July.

It is likely that these 45 records included some early and late season breeding attempts by the same individuals. Without marking females it is impossible to be certain about identities over the entire season, particularly because females usually disappeared from the pools a few days after their young left the web. However, the data from females with distinctive markings suggested that at least some individuals made two breeding attempts. At least five females, all of which were first seen with egg sacs in May or June, attempted to breed again in August or September. The numbers of days elapsing between the date on which they were first seen with an egg sac early in the season and that late in the season varied from 66 to 73 days. One female that was first recorded with a web, rather than an egg sac, was seen again with eggs 59 days later. This estimate is imprecise because egg sacs are carried for several weeks (see below) and I rarely knew whether the first sightings, during the early and late breeding attempts, were of newly-produced sacs or of ones that were close to hatching. Nevertheless, the interval between breeding attempts is in the order of nine or ten weeks.

It is unlikely that the females that were carrying eggs in late July and early August would have sufficient time to complete another breeding attempt. These females must either breed only once or, if they breed twice, their first attempt must have been missed very early in the season. The latter possibility is unlikely because, on the basis of a 60-70 day breeding cycle, a female making her second breeding attempt in mid-July would have been carrying eggs in early May. Females were first recorded as adult at the second sample round, on 14 May, but no females were recorded with eggs at this time. Bonnet (1930) found that captive females produced an average of three egg sacs but it seems very unlikely that more than two could be produced during the season in which they are active at this site.

3.3.2 Breeding success

During the 1992 season a total of 24 *D. plantarius* nursery webs were found in the routinely-monitored pools. The associated females were seen at 20 of these webs. No webs were found for 25 of the females that were seen carrying egg sacs (although four of these females may have made the webs at which no mother was found). I cannot be certain whether these females failed to build webs, whether they built webs away for the monitored pools or whether I failed to find the webs on the monitored pools. The latter is relatively unlikely since in July and early August the webs were large and conspicuous (see below). Most females built webs in vegetation directly above the area of pool on which they were most frequently seen with their egg sacs. However, it remains possible that other females moved to pools outside the recording area to find more suitable vegetation in which to build their webs. In July this was likely to have been possible because the water table was sufficiently high for water to remain in pools behind the irrigated line (see 3.4.1.1). It was less likely in August, particularly on Middle Fen, where the water levels were very low. At that stage the lack of suitable vegetation in which to build webs might well have resulted in failure to breed. On Middle Fen, by mid-July, the water in most pools was so low that it filled only the deepened central areas. Webs were built only in marginal emergent vegetation that was directly above the water and none of this remained. Females with egg sacs close to hatching were seen wandering on the dry banks of these pools.

The proportion of females with egg sacs for which no webs were subsequently found increased in late August and September (Fig. 3.5). Again, it is not possible to ascertain whether females were more likely to move to other pools before building their nursery webs at this time in the season or whether they were more likely to fail to build webs. Females appeared to be more mobile at this time; it was more difficult to predict where in a pool an individual would be found. However, there was strong circumstantial evidence that failure to build webs increased. Seven females with egg sacs were monitored every two days in mid-September. All showed typical pre-web-building behaviour, moving up into vegetation above the pools (Section 3.3.3), but all disappeared before any webs were built. One egg sac was found attached to a *C. mariscus* stem by a silk pad but had been abandoned before a web had been build, and had failed to hatch. One female was found dead with her egg sac in the vegetation in which she had been sitting at the pool edge. The cause of death was unclear but her abdomen appeared to be punctured.

All of these females were likely to have been making their second breeding attempt and several had one or more legs missing. This suggests that these females may have been in poorer condition than those breeding earlier, and hence less likely to succeed. The last web that was found with young was on 9 September and was much smaller than the webs seen earlier in the season. Late second breeding attempts may be likely to succeed only in years when the season is long. High winds and wet weather in late August and in September in 1992 may have made web building in sedge more difficult and early frosts in October curtailed the season rapidly. The last sighting of a female with an egg sac was on 30 September. Females breeding this late in the season obviously risk failure because of the weather. Late breeding attempts were more likely to have succeeded in the much warmer autumn in 1991. The evidence presented above (Section 3.2) suggests that this was indeed the case. Only one small individual was found on the Little Fen pools in warm sunshine on 13 October, following the first air frost and none were seen on any subsequent dates.

There was some evidence that the proportion the females with egg sacs that failed to built webs was higher on Middle than on Little Fen. I failed to find webs for 43% of the females with egg sacs on Little Fen but 75% on Middle Fen. This could have been due to relatively lower water levels on Middle Fen making the vegetation structure at the pool edge relatively unsuitable as suggested above. However, this result must be treated with caution because the absence of casual recording made the probability of webs being found on Middle Fen lower than on Little Fen. Although the probability of finding females with egg sacs was also lower, for the same reason, it was not proportionately as low because the duration of egg sac carrying was much greater than that of webs (Section 3.3.3 below).

Duffey (1991) suggested, on the basis of the proportions of females that were seen with egg sacs, that breeding success was much higher on Middle Fen than on Little Fen in 1991. Although this is contrary to the 1992 findings it is compatible with his finding that water levels on Middle Fen were higher than on Little Fen in 1991 (see Section 3.4.1.1). No nursery webs were found on either Fen in 1991. Water levels in the peak of the season in 1991 were lower than in

1992, and it seems possible that (as I have suggested occurred on some pools in Middle Fen in July and August 1992) the consequent lack of emergent vegetation in which to construct nursery webs, resulted in failure. This is further supported by my suggestion (Section 3.2) that the lack of half-grown individuals emerging from hibernation in spring 1992 is indicative of breeding failure in the peak of the 1991 season.

The probability of young being reared successfully from the nursery webs appeared to be very low. The data on this aspect of breeding success are poor because frequent visits are required to monitor the longevity of active webs. No web was found with young on two successive systematic sampling rounds. With three weeks between rounds this still gives a maximum longevity of nearly six weeks. Casual recording allowed more precise estimates but the critical intervals between the last sighting of a female with an egg sac and the first web sighting, and the last sighting of the web with young and the first without young, were rarely short enough to give small margins of error in the estimates. The minimum time in which young remained in webs varied from one to 12 days and the maximum time from eight to 15 days.

This large variability in the length of occupancy of webs suggests that the young may have been lost from most webs before they were due to leave. This conclusion is supported by several other observations. First, Duffey (pers.comm.) found that *D. plantarius* bred on a garden pond remained in the web for about a month. Duffey (1991) also reports that young remained in a nursery web on the Pevensey Levels for 25 days. Second, most webs from which young were lost rapidly were very torn. Predation by sedge warblers *Acrocephalus schoenobaenus* seemed a possible cause of these losses. The drought in July led to a concentration of these birds around the irrigated pools at a time when they were feeding young. They were often observed feeding in the vegetation around the pool margins. The young spiders react to disturbance by scattering rapidly from the webs and so it is possible that a proportion would escape predation. However, since the webs were usually badly torn, survival at this stage may be low. Kennett (1985) reported that spiders remained in nursery webs on Lopham and Redgrave Fen for less than a week but she did not consider the possibility that they were lost to predation.

3.3.3 Breeding biology

The disappearance of males relatively early in the season suggests that mating occurred at the beginning of the season and that second broods result from sperm storage.

Pregnant female spiders were extremely site faithful. They could be found in almost the same small area of pool with a very high predictability. Females were conspicuously pregnant for at least 16 days. They remained at the same site when their eggs sacs were produced. They carried egg sacs for well over 20 days. At least a week before the eggs hatched they climbed into the vegetation directly above the area in which they had been sitting. They remained there until they built their nursery webs around the egg sac, descending to the water only to dip their egg sacs. Some females disappeared from their usual site just before their eggs hatched. It was unclear whether these individuals were predated or whether they left to search for more suitable vegetation in which to build their webs. This cannot be resolved without marking individuals. I suggested above that females with egg sacs late in the season were more likely to move around the pools. It is possible that it became more difficult to find suitable sites for web construction. The reasons for this may include the fact that, later in the year, the taller vegetation blew around too much in high winds, that much of the marginal vegetation was broken down into the pools and that insolation at the pool margins was reduced.

All webs were built in emergent vegetation, directly over water. The average height of the webs was 40 cm above the water with a range from 10 to 80 cm. A wide range of vegetation was used for web sites. Of the 25 webs found, 46% were in *C. mariscus*, 32% in *Agrimonia eupatorium*, 8% in mixed vegetation (often *A.eupatorium* mixed with grass and sedge species) and 4% in *Juncus* species. These data do not necessarily imply that *C. mariscus* was the most favoured species for web sites: these percentages probably simply reflect the relative availability of the species around the pool edges. Other workers have suggested that vegetation structure is more important in determining suitability of web-building sites than the plant species (e.g. Jones 1982) and this also seemed likely at Lopham and Redgrave Fen. Webs were build both around the edges of pools and in 'islands' of emergent vegetation. In three pools, dense emergent tussocks of *C. mariscus* harboured concentrations of webs.

Although webs were usually built in sunny sites this was not uniformly true. Some webs that were built close the water were very shaded. It was unclear what determined the siting of webs. Webs were very patchily distributed between pools and several pools had clusters of webs in close proximity. These resulted both from several females building within a relatively short period of time and probably, to a lesser extent, from females building their second webs very close to their first. Aggregation of breeding females could have resulted either from a behavioural tendency to breed close to others, or could simply reflect the favourability of the pools for spiders in general. To attempt to distinguish between these possibilities I examined the relationship between the numbers of webs and the numbers of non-breeding spiders on the pools. There was a weak positive correlation (Spearman's Correlation Coefficient=0.297, $P<0.05$, $n=57$), suggesting that at least part of the variation was explained by the suitability of the pools to spiders.

When the young hatched from the egg sacs they remained in a tight cluster in the web. This behaviour made it impossible to estimate accurately their numbers. However, dissection of an egg sac belonging to the female that died before building her web (above) revealed a minimum of 286 spiderlings. Bonnet (1930) reported approximately 700 eggs per sac in captive-reared *D. plantarius*. This productivity suggests a capacity to increase rapidly under favourable conditions.

While the young were in the web the female remained close-by and actively defended it. After the young left the web the female remained for several days. There was some evidence that this behaviour was more pronounced when the young were lost at an early stage. The only observation of young dispersing from a nursery web on the fen was made in 1984 (Kennett 1985). The spiderlings climbed up tall vegetation above the web but none were seen to disperse by ballooning. Others ran down into the vegetation around the pool. Many of these were re-found in the same place on subsequent visits. No observations were made of spiderlings dispersing from the webs in 1992 and no concentrations of small spiders were found at the edges of the pools below the webs. However, no systematic searches were made of the vegetation on the pool banks near the web sites.

3.4 Factors influencing the distribution of spiders between pools

The obvious, overriding factor determining the distribution of spiders in 1991 and 1992 was the retention of water in the pools. In 1991 it was thought that very few pools other than those dug in 1986 and 1989 retained any water in mid and late summer. In 1992, this was probably true by August but more pools may have retained water earlier in the summer.

Amongst pools that retained water, the distribution of spiders between pools on both Middle and Little Fens was extremely patchy. A few pools were consistently good, many were consistently bad, and others were good only at some times in the season (numbers are listed by month and pool in Appendix 1).

Analyses of water chemistry (Ph, dissolved oxygen, BOD, Soluble Reactive Phosphorus and total phosphorus) in 1991 led Duffey (1991) to conclude that water quality was not necessarily the most important factor in determining the success of raft spiders on the pools.

In 1992 the only systematically measured feature that could help in accounting for spider numbers was the variation in water level. Management work was also likely to have influenced spider distributions although its application to the majority of pools makes it impossible to evaluate its impact. The possible importance of both of these factors is discussed below.

3.4.1 Water

3.4.1.1 Water Levels

Water levels in the pools on both Little and Middle Fens dropped rapidly during May. Figures 3.6 and 3.7 show the mean levels, relative to the early April datum (Section 2.2.3), for the irrigated and unirrigated pools on Little and Middle Fens respectively. By the end of May the mean levels were 10.5 cm below the April datum on Little Fen and 13.6 cm below the datum on Middle Fen. Irrigation began on 2 June. The water levels had recovered slightly by the second week of June, even in unirrigated pools.

In the unirrigated pools this recovery was short-lived. It was difficult to compare the losses from the unirrigated pools on the two Fens because the pools on Little Fen were shallower. Thus, on Little Fen, pools were dry at the measuring post when the measured loss was only 10-20 cm, while losses of 50-60 cm had the same effect in the Middle Fen pools. Levels in the unirrigated Middle fen pools fell progressively until early September, when a rapid recovery began. Of the eight unirrigated pools with measuring posts, four were dry at the posts from 15 August, although only one pool dried out completely, in early September. The two unirrigated pools monitored on Little Fen were dry at the posts by late July and the pools were virtually dry throughout from mid-August onwards.

On average, the irrigated pools on Little Fen maintained water levels at or a few centimetres above the datum throughout the summer. This compares with losses of 24-25 cm by late July in 1991 (Duffey 1991). On Middle Fen, however, the irrigation was inadequate to prevent a substantial fall, eventually of 23.5 cm, in mean levels during July and the first half of August. The losses on Middle Fen by early August in 1992 were thus similar to those measured in the absence of irrigation in 1991. This pattern of better maintenance of levels on Little than on Middle Fen is contrary to that found in the absence of irrigation in 1991, when the water loss on Little Fen 'was greater and took place earlier on Little Fen than on Middle Fen' (Duffey 1991).

These mean figures cover substantial variation between pools, much of which resulted from the proximity of the pool to the irrigation pipes. The seasonal changes in water levels for each individual pool are given in Appendix 2.

3.4.1.2 The effects of water levels on spider numbers

Changes in water levels in the pools may affect their suitability for spiders in several ways. Loss of water may reduce the availability of food and of suitable web-building sites (Section 3.3.3).

I found no significant correlation between the maximum numbers of spiders recorded and either the variance in water levels over the season (R_s=-0.16, ns, n=58), or the minimum water level (Spearman's R_s=0.25, ns, n=58) recorded during the season. There was a significant, positive relationship between the mean water levels and spider numbers, although it explained little of the variation in spider numbers (Spearman's R_s=0.31, $P<0.05$, n=58). These relationships could be investigated more rigorously with the 1991 and 1992 data sets but such analysis is beyond the scope of this report.

The present analysis suggests both that the relationships between water levels and spider numbers are complex and that other factors must be of relatively greater importance in determining the suitability of individual pools. The unirrigated series of pools on Middle Fen demonstrate this complexity most clearly. No spiders were recorded on these pools in May and June. In June the water surfaces in these pools were covered by an oily film but this was dispersed by heavy rain on 13 July and did not re-develop to the same extent. From mid-July onwards spiders were recorded on six pools in this area, despite very low water levels (see Appendix 1). The bottoms of these pools and the stems of the emergent vegetation were thickly encrusted with irony deposits, the banks were very steep and the surrounding vegetation comprised dense, coarse grassland - all conditions which had previously been thought to be unfavourable to *D. plantarius* on the fen. It is possible that these pools may have been the only ones that retained water in that part of the fen and that spiders may have moved on to them when no more suitable alternatives were available. One large female spider was seen on this series of pools in 1991 but the presence of spiders of at least two sizes in 1992 suggests that more than one breeding attempt must have been successful in that area of the fen in 1991.

3.4.2 Management

3.4.2.1 Management operations

Two management operations, designed to reduce shading in and around the pools, were carried out in 1992. In the third week of April the vegetation was cut around those pools that had been recorded routinely in 1991 (see Figs. 2.1 and 2.2). Only the pools within irrigated areas were managed. Pools within the irrigated series that were not monitored in 1991 and early 1992, and the unirrigated pools 1 and 2 on Little Fen and pools 21 on 28 on Middle Fen, were left uncut. Cutting was done with a single sweep of a brush cutter, aligned at approximately 45° to the water. This meant that emergent vegetation around the margin was cut at water level and the vegetation on the banks was left progressively taller, up to about a meter from the pool edge. The cut vegetation was raked-up and removed from the fen.

In the second half of June a long-handled cutting blade was used to cut tall emergent vegetation (mostly *Phragmites australis*) from the centres of the pools. It was originally planned that this work would be carried out in August but by mid-summer the vegetation growth in the pools was such that earlier cutting was thought necessary. Cutting was done with great care to avoid disturbance to the water and particularly to the marginal vegetation. Cutting, and subsequent removal of cut material, was all done from one point on the bank of each pool.

3.3.2.2 Influence of management on spiders

Because management operations were carried out on all routinely monitored, irrigated pools it was not possible to evaluate their effects on spider numbers (see 4.2 below). However, since spiders appear to prefer sunny sites for many activities, preventing over-shading of the water by dense vegetation is likely to be beneficial. This subject is considered further in Section 4.

4. CONCLUSIONS AND RECOMMENDATIONS

The numbers of *D. plantarius* on Lopham and Redgrave Fen in 1992 remained extremely low. Evidence of improved breeding success in the peak of the season in 1992, relative to that in 1991, was counterbalanced by evidence of poorer breeding success in late summer. The presence of water is an essential pre-requisite for maintenance of the population. Because of the overriding imperative of ensuring this supply in the face of losses from abstraction, compounded by three years of drought, the 1991 and 1992 surveys concentrated on the primary aim of detecting evidence of further decline in the population remaining on the pools with the most reliable water supply. Management work in 1992 concentrated on the equally important aim of ensuring that these pools were not infilled by vegetation. Whilst these aims must remain at the core of future work, other subsidiary aims have become more pressing if the future of this population is to be adequately safeguarded and if we are to be in a position to monitor its recovery, should such occur if the borehole is closed.

I have listed below the objectives that I believe are now most appropriate and the changes that I feel need to be made to the present programme of monitoring and management to ensure the most cost-effective use of funds in aiding the recovery of this population. The first two points deal with modifying the monitoring methods so that recovery as well as further decline can be measured. The next four points deal with different aspects of management: the first two concern the information that is needed to formulate better management strategies, the third with demonstrating whether or not management brings positive benefits for the population and the last with the management work needed in 1993.

4.1 Monitoring recovery

By monitoring pools within such a restricted area of the fen, and which are probably the last stronghold of *D. plantarius*, the information that can be derived on the status of the population is likely to be restricted to assessing whether or not the population is approaching extinction. If the population expands it is more likely that it will do so by occupying a wider area than by increasing substantially its density on the present pools. The ranges of numbers that measured per pool in 1992 were similar to those reported by Thornhill (1985) at a time when the population was much larger. It is vital that any recovery is monitored. Although a permanent low-level monitoring programme is essential for such a rare species, evidence of a sustained recovery would mark the end of the requirement for intensive expenditure on special protection measures.

Establishment of a baseline sample of pools over the area into which the population is initially likely to expand from the present foci, if water levels are restored, is an essential pre-requisite for monitoring recovery. This would require mapping the pools in the area, followed by random selection of a sample of pools for routine monitoring. Mapping would have to be carried out in late winter, with the aid of aerial photographs, before the vegetation obscures the pools. Access to the sample pools would also have to be established at this stage. I suggest that a sample of 20 to 25 pools on each Fen is used. Since the primary aim of this exercise is estimation of the numbers of spiders on the pools, this may be best achieved by three monitoring round each year in the early, mid and late season. Each round may involve two visits to each pool on sequential days (see 4.2 below). Assuming that the two series of pools can each be monitored in two days, this gives 12 days work in addition to the time needed for identifying the sample pools in the winter. The data collected should be counts of numbers on each pool, sub-divided by sex (for adults and large immatures) and approximate and age/size categories. The latter information is needed both to improve the accuracy of the population estimate and to indicate the sectors of the population involved in colonisation.

4.2 Validation of counting methods

Single counts of pools will inevitably lead to some spiders being overlooked. This results in underestimation of the population at any one point in time. At present we have no measure of the extent of this underestimation. While the population appears to be at such a low level this is important information. The extent of this underestimate is also likely to be biased by a variety of factors (Section 3.1). In 1991 the weekly interval between counts made these problems less important than in 1992 because the four counts in each monthly period could effectively be used as replicate counts for that month. If even lower sampling frequencies are employed in future years the accuracy of estimates based on single counts should be examined.

This could be achieved by recording spiders on a relatively small number of pools on a number of consecutive days. As far as possible, the spiders should be identified individually (by size, sex, colour *etc.*) and the correspondence between the individuals seen on successive days examined. Ideally, the maximum number of days taken, on any pool, until no new individuals are found should be used as the basis for single censuses. In practise this is unlikely to be feasible but this exercise would nevertheless tell us whether (for example) two counts would give substantially better estimates than one. The study should also be designed to allow some quantification of biases in the detectability of the spiders. Replicated samples of pools should be chosen which differ markedly in features that are thought to cause bias, and counts should also be made in differing weather conditions and at different times of day. It is likely that this work would involve around 16 pools and could be completed (including analyses) in five days.

4.3 Optimising management strategies

We remain fundamentally ignorant of the factors that cause spiders to favour some pools and not others. There are no quantitative data that explain substantial amounts of the variation in spider numbers between pools. In 1992 the occurrence of spiders in some unmanaged pools and unirrigated pools suggests that it would be cost effective to try to answer this problem.

It may be possible to achieve this with relatively few days work. The effects of a number of variables could be examined by multiple regression analysis of the existing two year's data in conjunction with measurement of additional variables on the pools. Comparison should also be made between the numbers of spiders on pools in 1991 and 1992 to see whether the same pools are consistently favoured over time.

4.4 Minimising the risks of management

While better information is needed on the habitat requirements of the spiders if more effective management regimes are to be designed, a better understanding of the spider's phenology and breeding behaviour is also needed to ensure that management does not have any direct deleterious effects. Management operations which improve the habitat for the spiders but which destroy part of the population must be avoided when the population is at such a low level. The information on the phenology of breeding obtained by identification of individuals in 1992 gives some indications of the importance of this. However, our information particularly on the early and late part of the season, is still inadequate to provide a sound basis for management advice. A programme of more detailed monitoring of the phenology of the spider's life cycle is needed. This would be much more effectively addressed by collecting detailed information, at very frequent intervals, on a small number of individual spiders, within a restricted area, than by large-scale monitoring. Individual marking of adults as soon as they mature in the spring would result in much more informative data on their reproductive behaviour and their movements during the season than it has been possible to collect to-date.

4.5 Assessing the effectiveness of management

The effectiveness of any management regimes employed in the future should be rigorously assessed. To achieve this, management operations should be restricted to a randomised sample of pools, and the numbers of spiders on these pools compared with those on unmanaged pools. As a result of increasing the number of pools monitored in summer 1992, baseline data are available for monitoring change on 34 pools on each fen. Because leaving pools unmanaged is believed to be a more risky strategy than managing them, I propose that between 12 and 14 pools in each series are left unmanaged. On Middle Fen some pools in the unirrigated sub-series, all of which were left unmanaged in 1992, should be managed in 1993. Because the two sets of pools on Middle Fen differ so substantially in many respects, the sample should be stratified between them. It may be adequate to assess the effects of management on spider numbers by monitoring the pools only once, in the peak of the season.

The comprehensive baseline data for these pools would enable two independent assessments of the effects of management to be made. Comparison could be made not only between managed and unmanaged pools within the year but also between the relative changes in numbers in managed and unmanaged pools between years. These two assessments, and the sample size available, should be adequate to evaluate the effectiveness of management. However, because of the large numbers of other variables that are likely to affect spider numbers, non-significant results should be treated with caution. Failure to detect significant effects of management would not necessarily indicate that management is ineffective. It should also be born in mind there may be a delay between carrying out management operations and any effects on spider numbers. Thus, for example, reed cutting in the pools in June 1992 may not have affected numbers in 1992 but, by 1993, pools in which reed were left uncut may be too shaded to provide favourable habitat.

4.6 What management?

In the absence of information that could lead to the design of better management regimes, it seems prudent to continue the current policy of management to retain open water and reduce shading around the pool margins. The possibility that breeding attempts may be made earlier in the year than observed in the 1992 survey, suggests that cutting the vegetation in the water margin and on the banks of the pools should be done in late March, rather than in late April. Consideration should be given to advisability of removing cut material from the site earlier in the spring, when much of the population is likely to be in hibernation.

Although there are substantial practical difficulties involved in changing the profile of the pools, serious consideration should be given to modifying the pools on Middle Fen which had little suitable emergent vegetation for nursery web construction in July and August, when the water levels fell. Creation of segments in the pools in which the profile slopes gently, rather than having a shelf separating a deep centre from a shallow edge, should allow the establishment of emergent vegetation at a greater range of depths.

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FIG. 3.1 Numbers of *D. plantarius* in different age classes on Little Fen

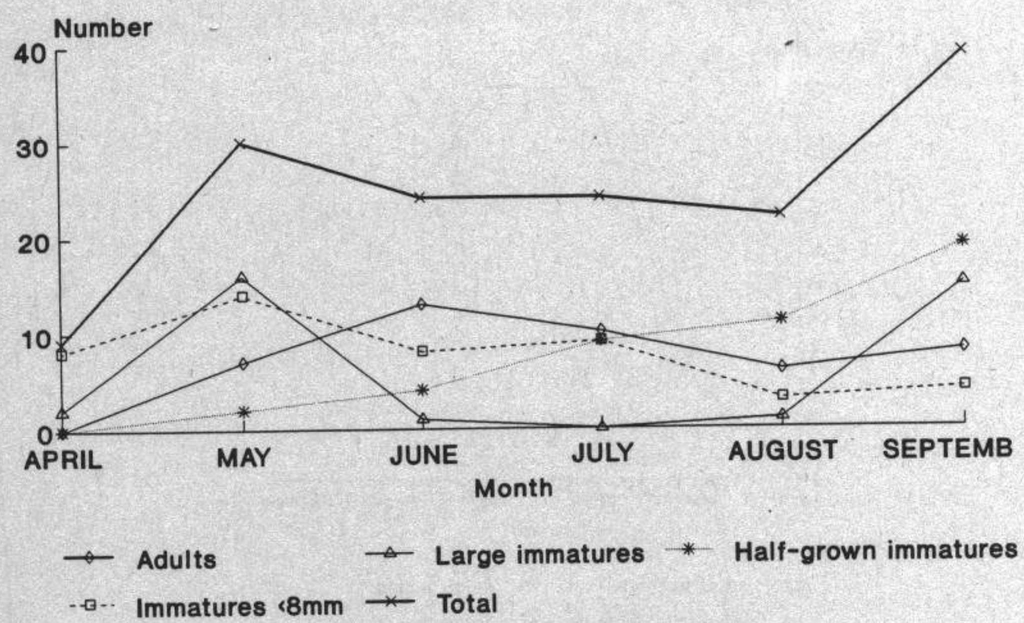
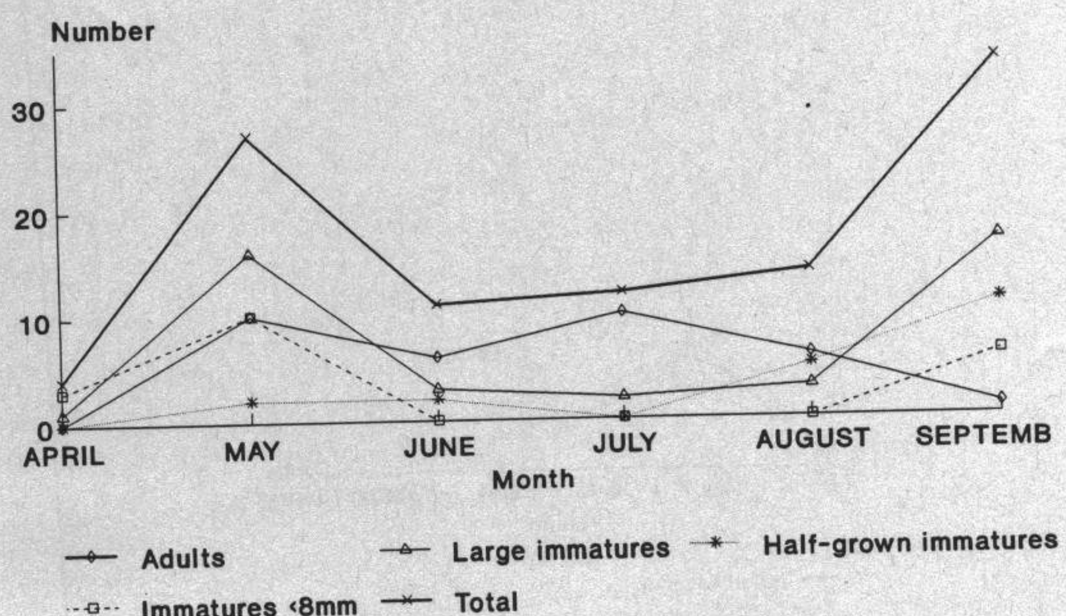


FIG. 3.2 Numbers of *D. plantarius* in different age classes on Middle Fen



data are mean monthly maximum counts
for 29 pools

FIG. 3.3 Numbers of adult and sub-adult males and females on Little Fen

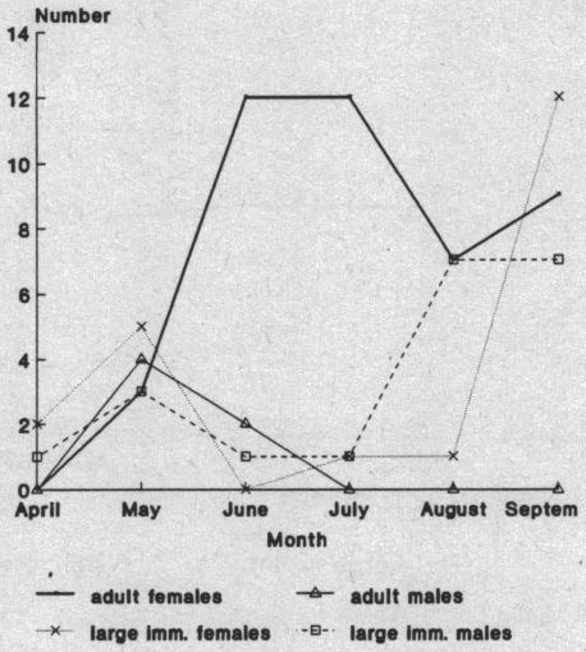
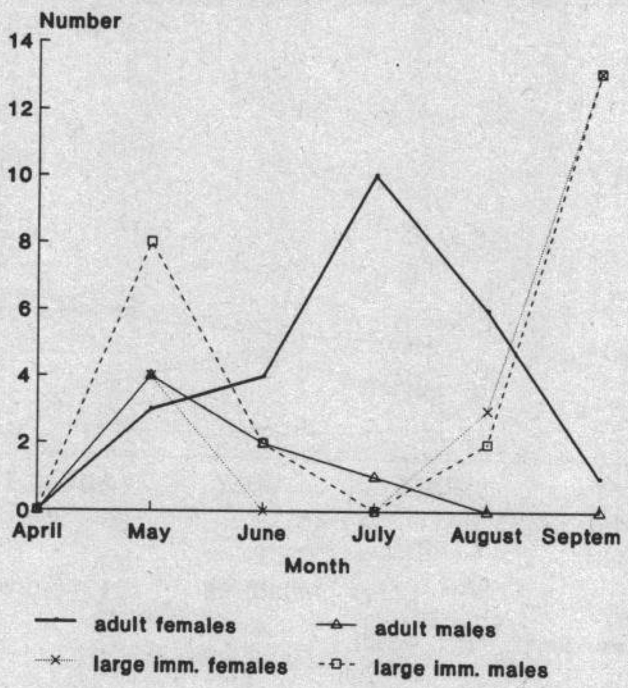


FIG. 3.4 Numbers of adult and sub-adult males and females on Middle Fen



Data are sums of monthly maximum counts for 32 pools

FIG. 3.5 Total numbers of females with egg sacs and of webs in 1991

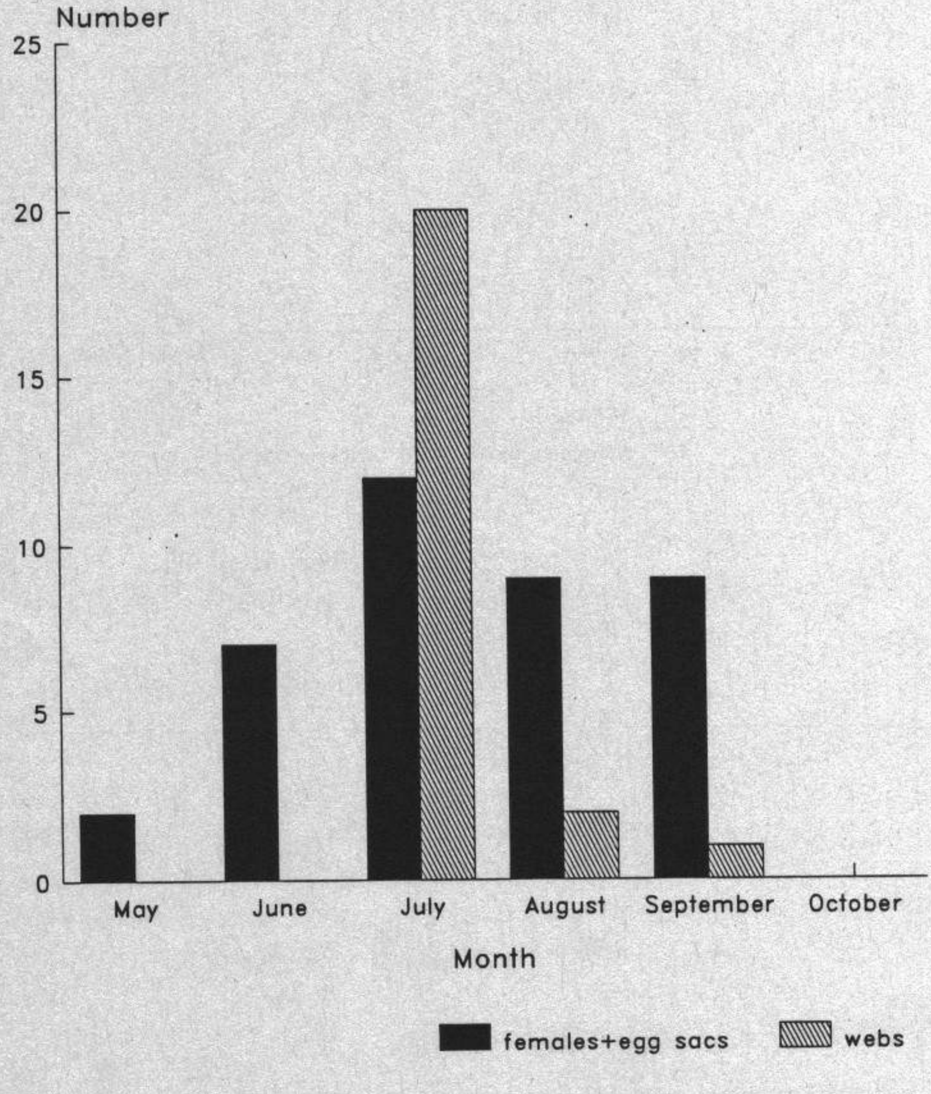


FIG. 3.6 Changes in water level in pools on Little Fen in 1992

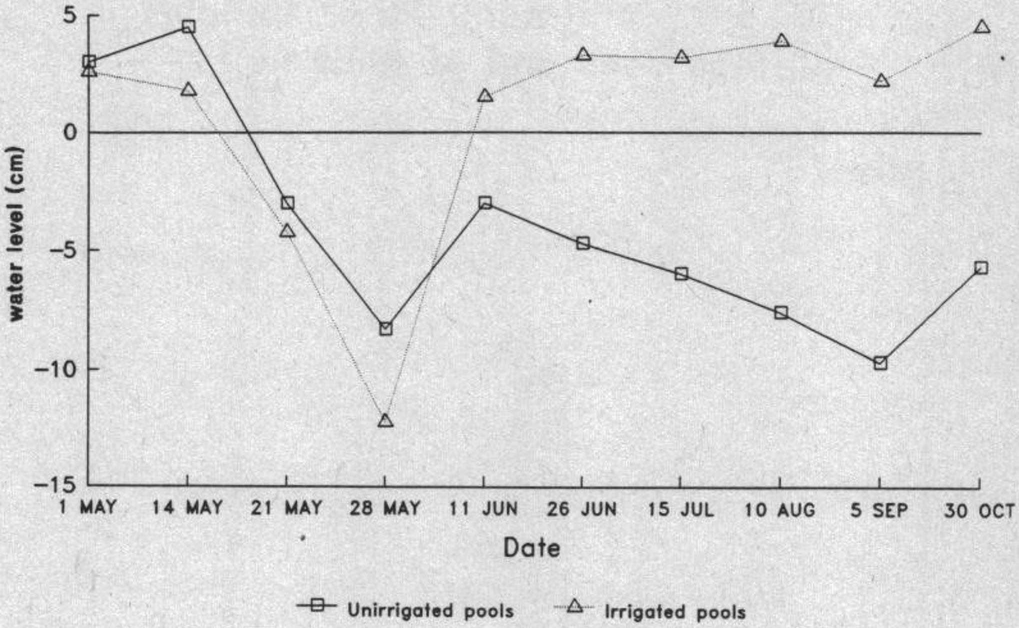
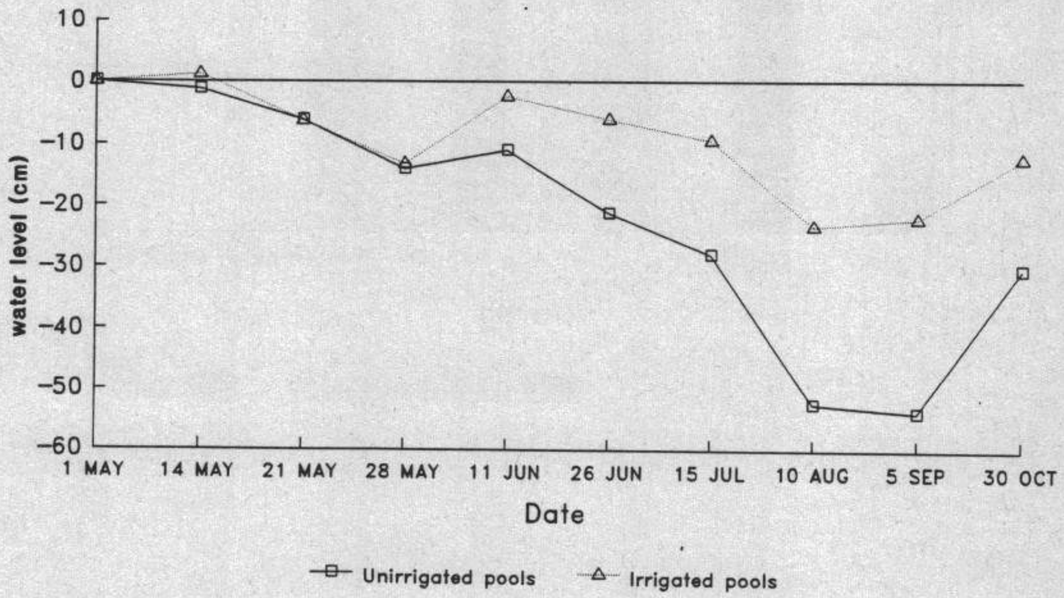


FIG. 3.7 Changes in water level in pools on Middle Fen in 1992



Levels are relative to the water table in early April. Irrigation started on 2 June

Appendix 1 NUMBERS OF SPIDERS ON INDIVIDUAL POOLS

The count data in this appendix[1] are monthly summaries, for each pool, of the maximum numbers of spiders recorded on any day in the month.

The pools are listed by Fen (L = Little Fen, M = Middle Fen) and number. The numbers of spiders are sub-divided by growth stage (A, adult; L, large immature; M, half-grown; S small immature) and by sex (M, F or '-' (where juveniles were not sexed)).

[1] The data in this appendix should not be cited or used in any publication without the permission of English Nature, The Suffolk Wildlife Trust and the author.

Fen	Pool No.	Mth.	Stage	Sex	Maximum count
L	2	May	L	-	1
L	3	April	L	M	1
L	3	April	S	-	2
L	3	May	A	M	1
L	3	May	S	M	1
L	3	June	S	-	1
L	3	Sept.	L	F	1
L	3	Sept.	L	M	1
L	3	Sept.	M	-	1
L	3	Sept.	M	F	1
L	3	Sept.	S	-	1
L	4	Sept.	L	M	1
L	5	May	A	F	1
L	5	May	L	F	1
L	5	May	L	M	1
L	5	May	S	F	2
L	5	May	S	M	1
L	5	June	A	F	1
L	5	June	M	-	1
L	5	July	A	F	2
L	5	July	M	-	1
L	5	July	M	F	1
L	5	July	M	M	1
L	5	July	S	-	1
L	5	July	S	F	1
L	5	Sept.	M	M	1
L	6	April	S	-	1
L	6	June	L	M	1
L	6	July	A	F	2
L	6	Sept.	L	F	2
L	7	Sept.	A	F	1
L	7	Sept.	L	F	1
L	7a	Sept.	L	M	1
L	7a	Sept.	M	M	1
L	8	April	S	-	1
L	8	May	L	M	1
L	8	May	S	M	1
L	8	June	A	F	1
L	8	June	A	M	1
L	8	July	A	F	1
L	8	Aug.	M	-	1
L	8	Sept.	A	F	1
L	8	Sept.	M	-	1
L	9	May	A	M	1
L	10	May	A	M	1
L	10	May	L	-	1
L	10	May	S	F	1
L	10	May	S	M	1
L	10	June	A	F	1
L	10	Aug.	M	F	1
L	10	Sept.	L	M	1
L	10	Sept.	M	-	1
L	10	Sept.	M	M	1
L	11	April	S	-	1
L	11	May	A	F	1

Fen	Pool No.	Mth.	Stage	SEX	Maximum count
L	11	May	S	F	1
L	11	May	S	M	1
L	12	May	A	F	1
L	12	May	L	-	1
L	12	June	A	F	1
L	13	May	L	M	1
L	13	June	S	-	1
L	13	Aug.	A	F	1
L	13	Aug.	L	F	1
L	13	Sept.	A	F	2
L	13	Sept.	M	F	1
L	14	April	L	-	1
L	14	May	A	M	1
L	14	May	L	F	2
L	14	May	L	M	2
L	14	June	A	F	2
L	14	June	A	M	1
L	14	Aug.	A	F	1
L	14	Sept.	S	-	1
L	15	April	S	-	1
L	15	May	L	-	1
L	15	May	L	F	1
L	15	May	S	F	1
L	15	June	A	F	1
L	15	June	M	F	1
L	15	June	S	-	2
L	15	July	A	F	1
L	15	July	S	-	2
L	15	Aug.	M	-	1
L	15	Aug.	M	F	1
L	15	Aug.	M	M	1
L	15	Aug.	S	-	1
L	15	Sept.	L	F	2
L	15	Sept.	M	-	1
L	15	Sept.	M	F	1
L	16	May	L	F	1
L	16	May	S	F	1
L	16	May	S	M	1
L	16	June	A	F	2
L	16	June	S	-	1
L	16	July	A	F	1
L	16	July	M	F	1
L	16	July	M	M	1
L	16	July	S	-	1
L	16	Aug.	A	F	3
L	16	Aug.	M	-	2
L	16	Aug.	M	F	1
L	16	Aug.	S	-	2
L	16	Sept.	A	F	4
L	16	Sept.	L	-	1
L	16	Sept.	L	F	2
L	16	Sept.	L	M	2
L	16	Sept.	M	-	2
L	16	Sept.	M	F	1
L	16	Sept.	M	M	2

Fen	Pool No.	Mth.	Stage	Sex	Maximum count
L	17	May	M	-	1
L	17	June	M	F	1
L	17	July	M	-	2
L	17	July	S	-	2
L	17	Sept.	L	F	1
L	17	Sept.	M	F	1
L	17	Sept.	M	M	1
L	18	April	S	-	1
L	18	May	L	-	1
L	18	May	L	F	1
L	18	May	S	F	1
L	18	May	S	M	1
L	18	June	M	-	1
L	18	July	A	F	1
L	18	Aug.	M	-	2
L	18	Sept.	L	F	2
L	18	Sept.	L	M	1
L	18	Sept.	M	F	1
L	18	Sept.	S	-	1
L	19	May	M	-	1
L	19	June	A	F	1
L	19	Sept.	S	-	1
L	20	May	L	-	1
L	20	May	S	F	1
L	20	May	S	M	1
L	20	June	S	-	1
L	20	July	A	F	1
L	20	July	S	-	1
L	20	Sept.	M	-	1
L	22	May	L	F	1
L	23	April	S	-	1
L	23	Aug.	M	F	1
L	25	Aug.	M	-	1
L	25	Sept.	M	F	1
L	26	June	A	F	1
L	26	June	S	-	2
L	26	July	M	-	3
L	26	July	M	F	1
L	26	July	S	-	1
L	26	Aug.	M	M	1
L	26	Sept.	M	F	1
L	27	June	A	F	1
L	27	July	A	F	1
L	27	Aug.	A	F	1
L	28	July	S	-	1
M	0	April	S	-	1
M	0	May	L	F	1
M	0	May	L	M	1
M	0	May	S	-	4
M	0	May	S	F	1
M	0	June	L	M	2
M	0	Sept.	A	F	1
M	0	Sept.	M	M	1
M	1	May	L	-	1
M	1	May	L	M	2

Fen	Pool No.	Mth.	Stage	Sex	Maximum count
M	1	Sept.	S	-	1
M	2	May	S	-	1
M	2	July	A	F	1
M	3	May	L	M	1
M	3	July	A	M	1
M	3	Sept.	M	F	1
M	4	May	L	M	1
M	5	May	L	F	1
M	5	June	A	F	1
M	5	July	A	F	1
M	5	Aug.	A	F	1
M	6	May	A	-	2
M	6	May	I	-	1
M	6	May	L	-	1
M	6	July	A	F	1
M	6	Aug.	M	F	1
M	7	April	S	-	1
M	7	May	A	-	1
M	7	May	L	-	2
M	7	May	L	M	1
M	7	May	S	F	1
M	7	May	S	M	1
M	7	June	A	F	2
M	7	July	A	F	2
M	7	Aug.	A	F	2
M	7	Sept.	M	F	2
M	7	Sept.	M	M	1
M	8	May	A	M	1
M	8	May	S	F	1
M	8	Aug.	M	F	1
M	9	May	A	F	1
M	9	May	L	-	2
M	9	May	L	F	1
M	9	May	S	F	1
M	9	June	I	M	1
M	9	July	A	F	1
M	9	Aug.	M	M	1
M	9	Sept.	S	-	1
M	10	April	S	-	1
M	10	May	A	F	1
M	10	May	L	-	1
M	10	May	L	F	1
M	10	June	A	M	1
M	10	Aug.	A	F	1
M	10	Aug.	L	M	2
M	10	Aug.	M	-	1
M	10	Sept.	L	F	1
M	10	Sept.	M	M	1
M	10	Sept.	S	-	3
M	11	May	A	M	1
M	12	July	A	F	1
M	12	Aug.	A	F	1
M	13	May	A	F	1
M	13	July	A	F	1
M	13	Aug.	A	F	1

Fen	Pool No.	Mth.	Stage	Sex	Maximum count
M	13	Sept.	S	-	1
M	14	April	M	-	1
M	14	May	L	M	1
M	14	May	M	-	1
M	14	Sept.	L	F	1
M	14	Sept.	M	F	1
M	15	May	A	M	1
M	15	May	S	M	1
M	15	June	A	M	1
M	15	Sept.	L	F	2
M	16	Sept.	M	M	1
M	17	May	A	M	1
M	17	May	L	M	1
M	17	May	M	-	1
M	17	June	A	F	1
M	17	June	M	-	2
M	17	July	A	F	1
M	17	Aug.	M	-	1
M	18	Sept.	L	F	1
M	18	Sept.	M	F	1
M	19	Sept.	L	M	1
M	19	Sept.	M	F	1
M	20	July	M	-	1
M	20	Sept.	L	F	3
M	20	Sept.	L	M	1
M	22	July	M	F	1
M	22	Sept.	L	F	1
M	22	Sept.	L	M	4
M	22	Sept.	M	F	1
M	24	Aug.	L	F	1
M	24	Sept.	L	F	1
M	24	Sept.	L	M	2

Appendix 2 WATER LEVELS ON INDIVIDUAL POOLS

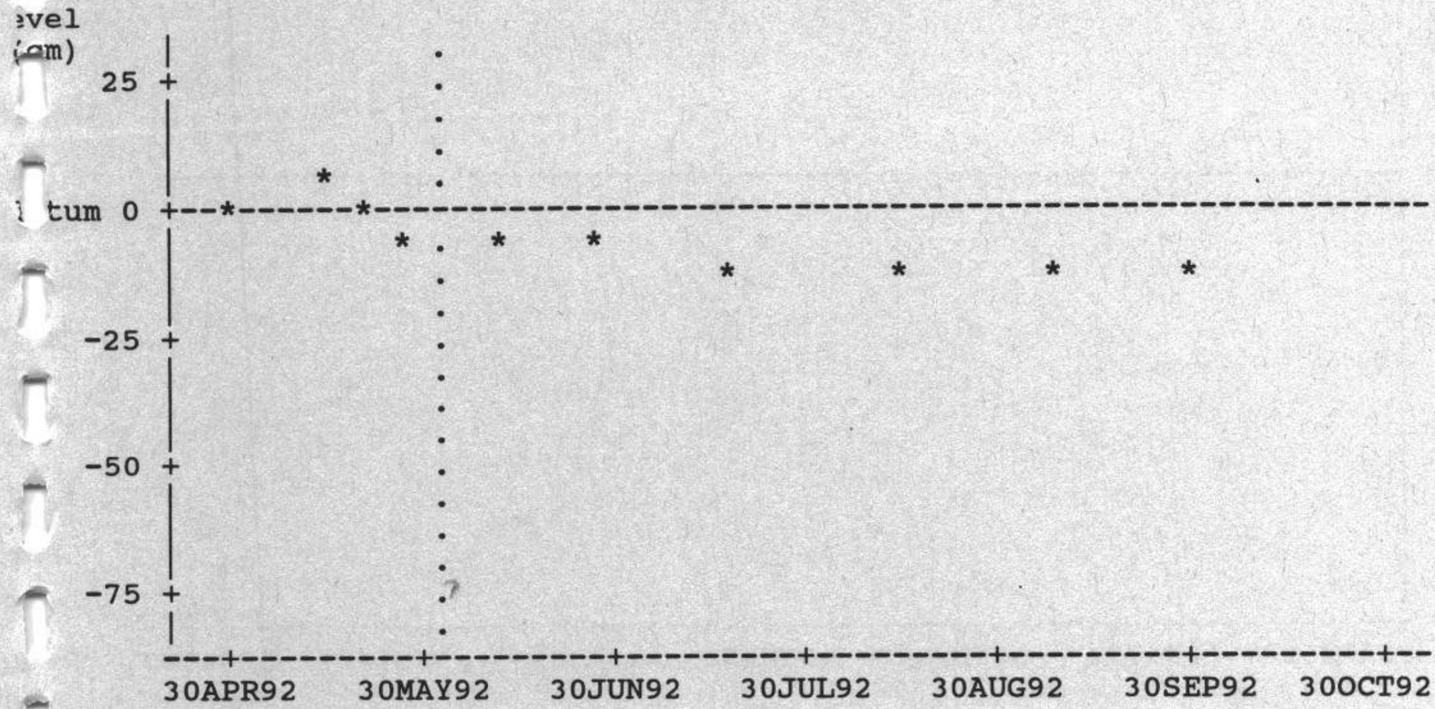
The following figures show the water levels in 29 pools on each of Little and Middle Fens[1].

Pool numbers 1 and 2 on Little Fen and 21 to 28 on Middle Fen were beyond the influence of the piped water supply. Irrigation began on 2 June. This date is marked by a vertical dotted line on each figure.

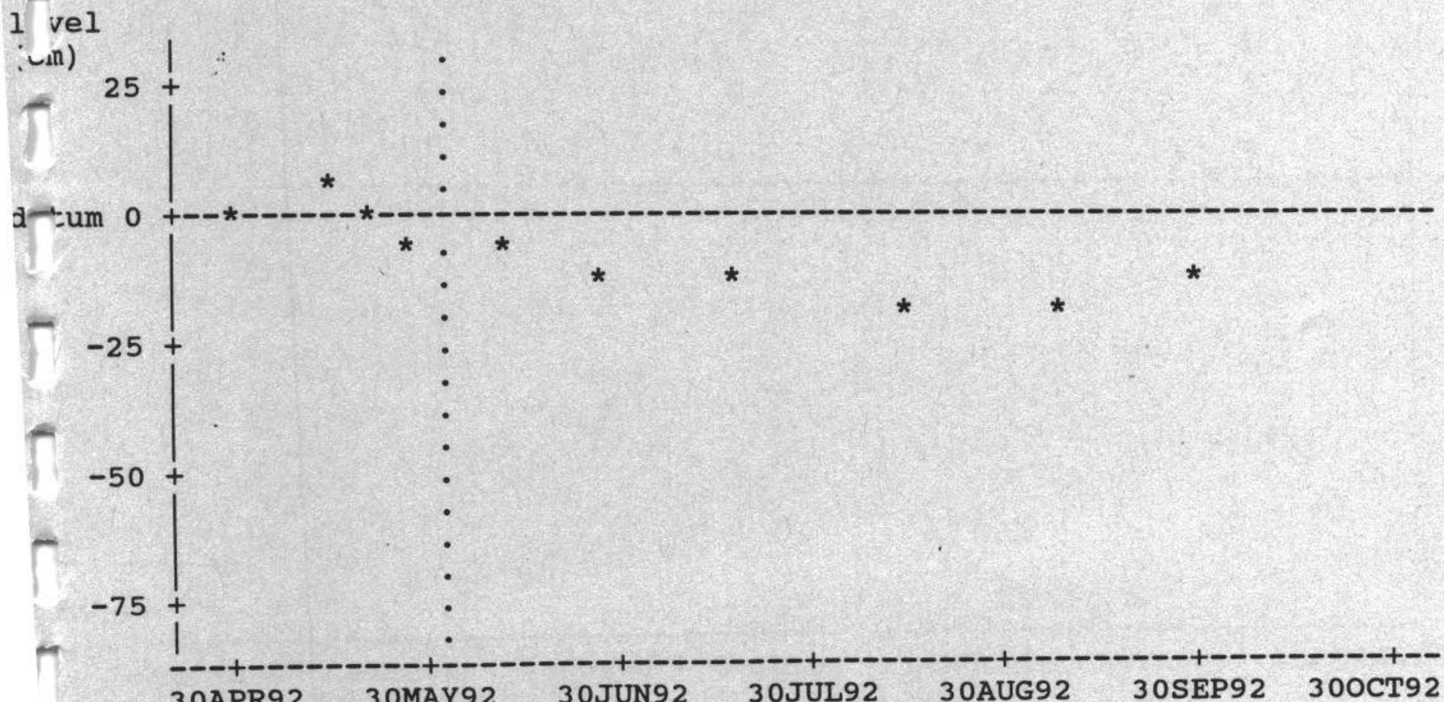
Pools that were dry at the measuring post are indicated are indicated by a letter 'D' by the appropriate date/s and pools that were completely dry with 'E' (the posts were rarely in the deepest part of the pool).

1. The data in this appendix should not be cited or used in any publication without the permission of English Nature, The Suffolk Wildlife Trust and the author.

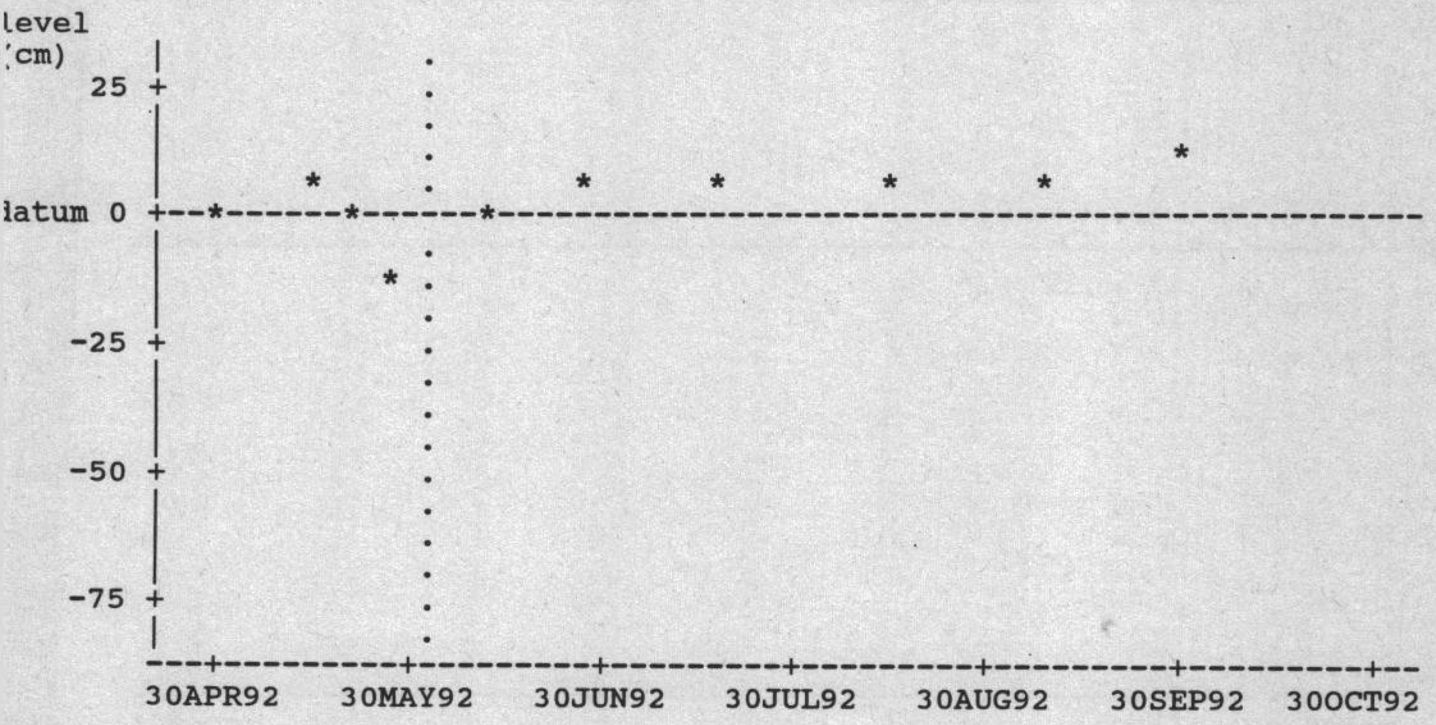
CHANGES IN WATER LEVEL IN POOL 1, LITTLE FEN, DURING 1992



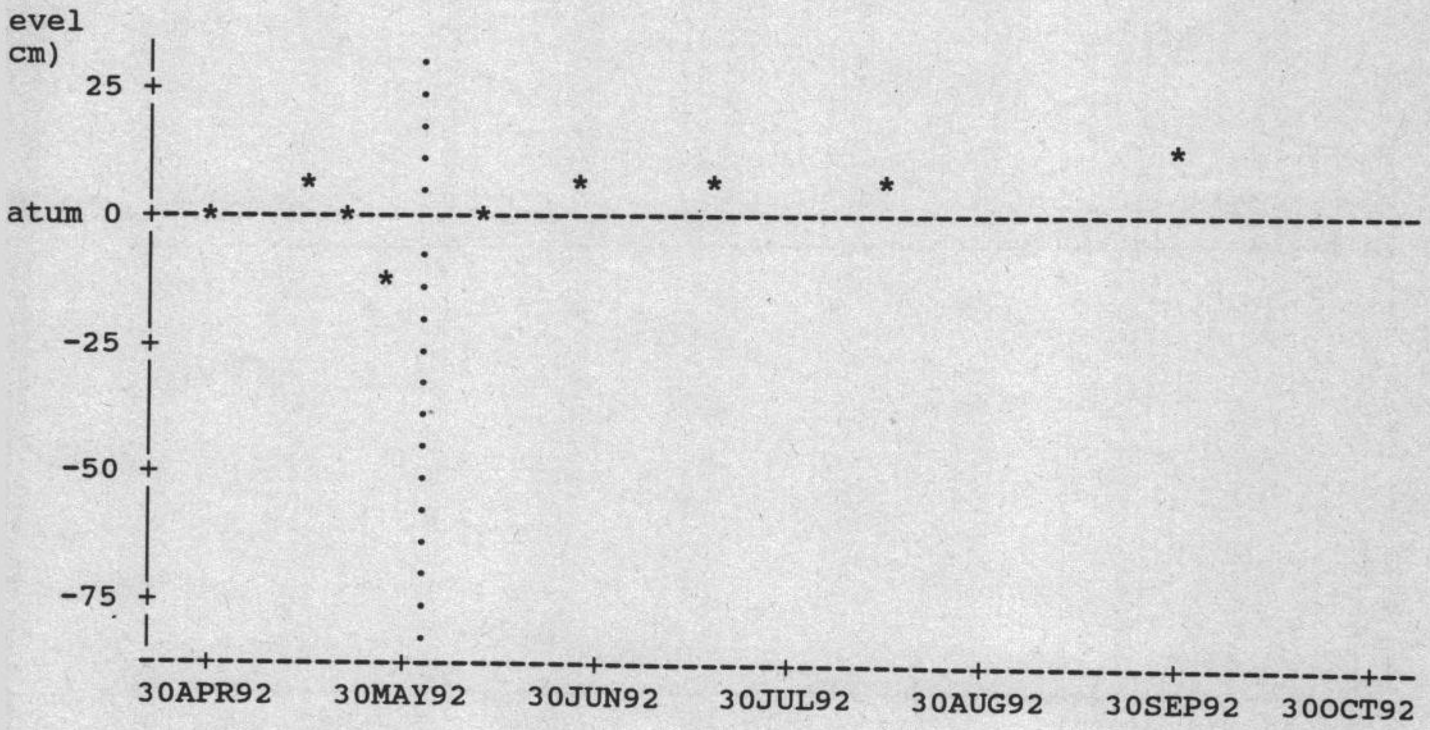
CHANGES IN WATER LEVEL IN POOL 2, LITTLE FEN, DURING 1992



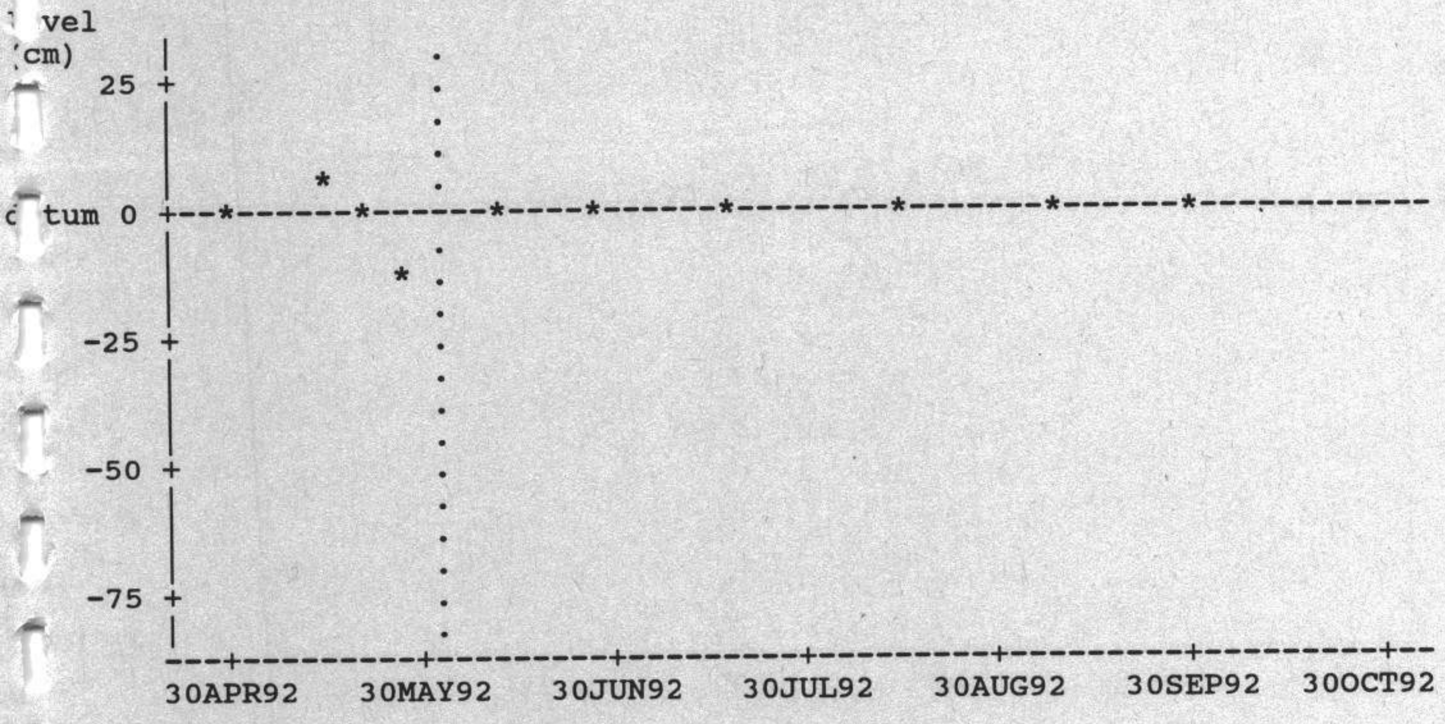
CHANGES IN WATER LEVEL IN POOL 3, LITTLE FEN, DURING 1992



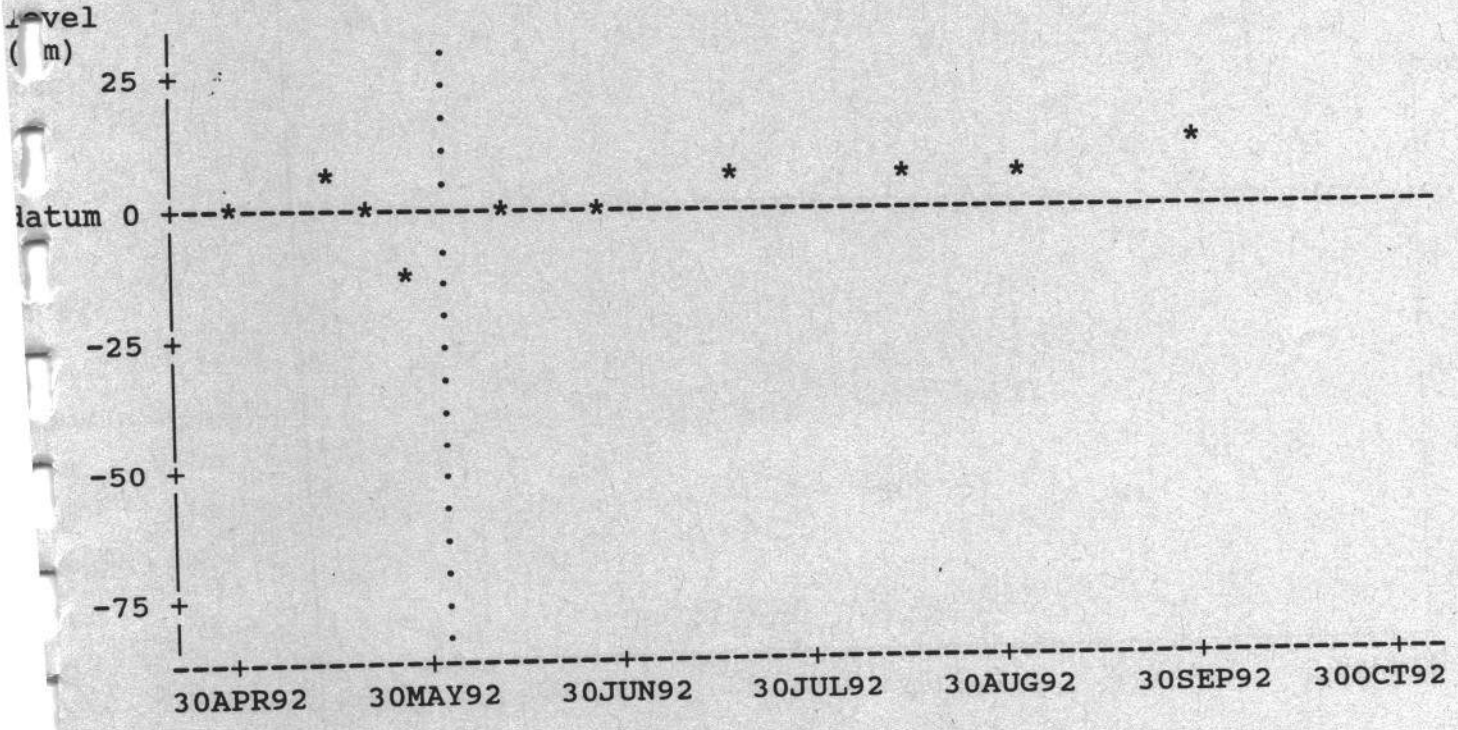
CHANGES IN WATER LEVEL IN POOL 4, LITTLE FEN, DURING 1992



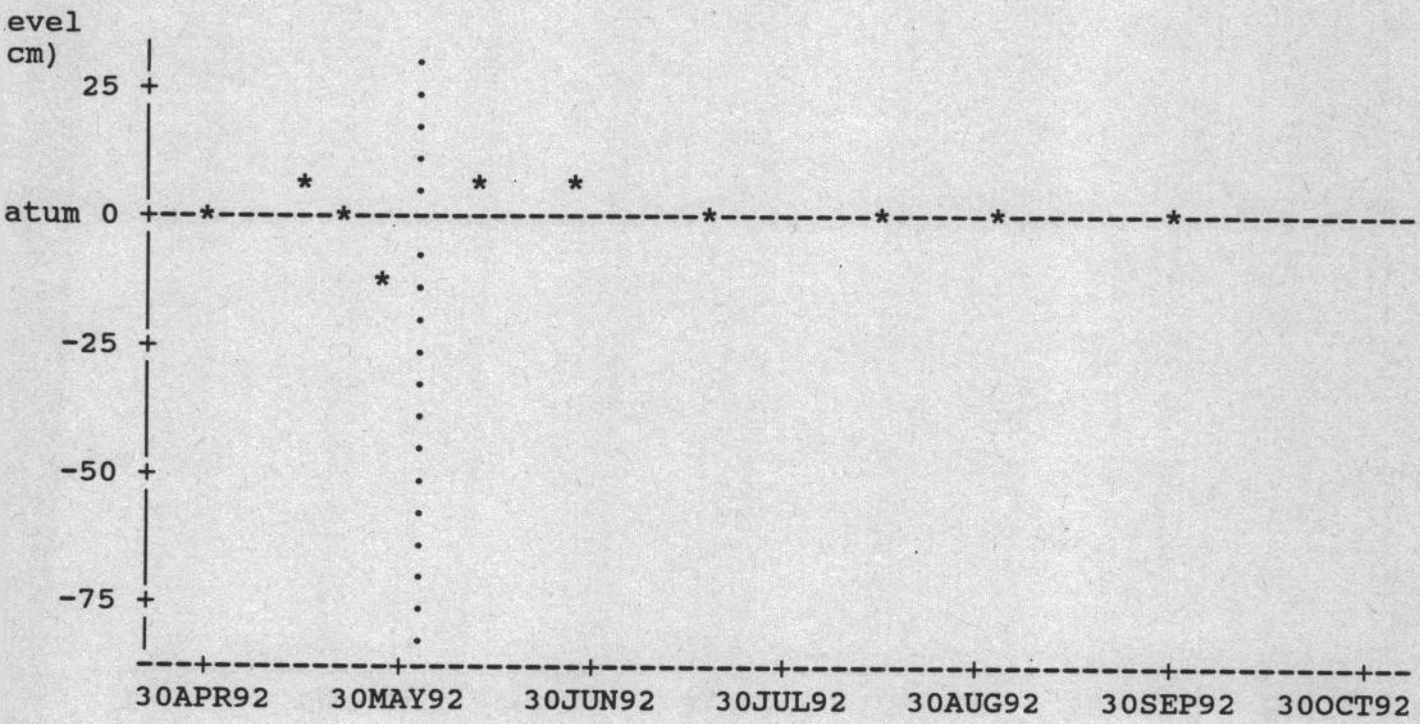
CHANGES IN WATER LEVEL IN POOL 5, LITTLE FEN, DURING 1992



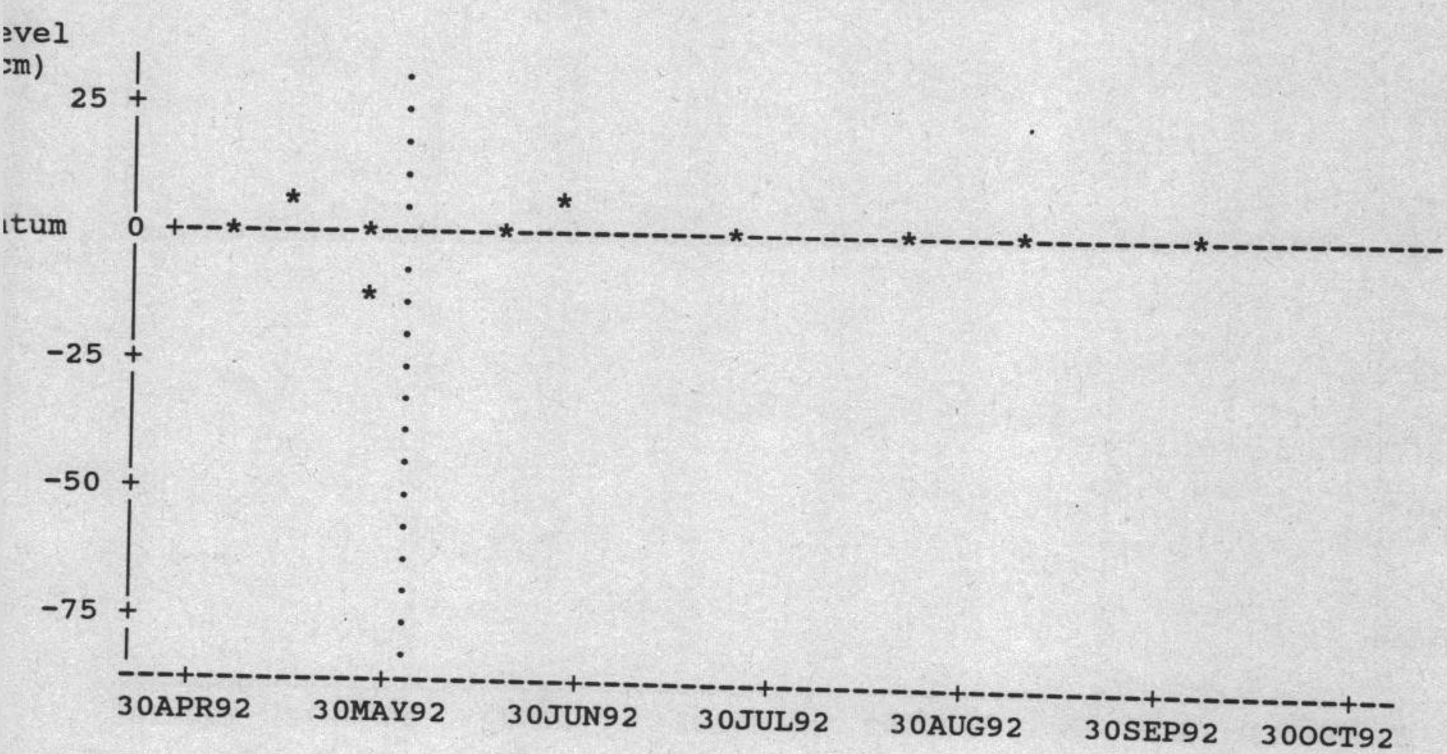
CHANGES IN WATER LEVEL IN POOL 6, LITTLE FEN, DURING 1992



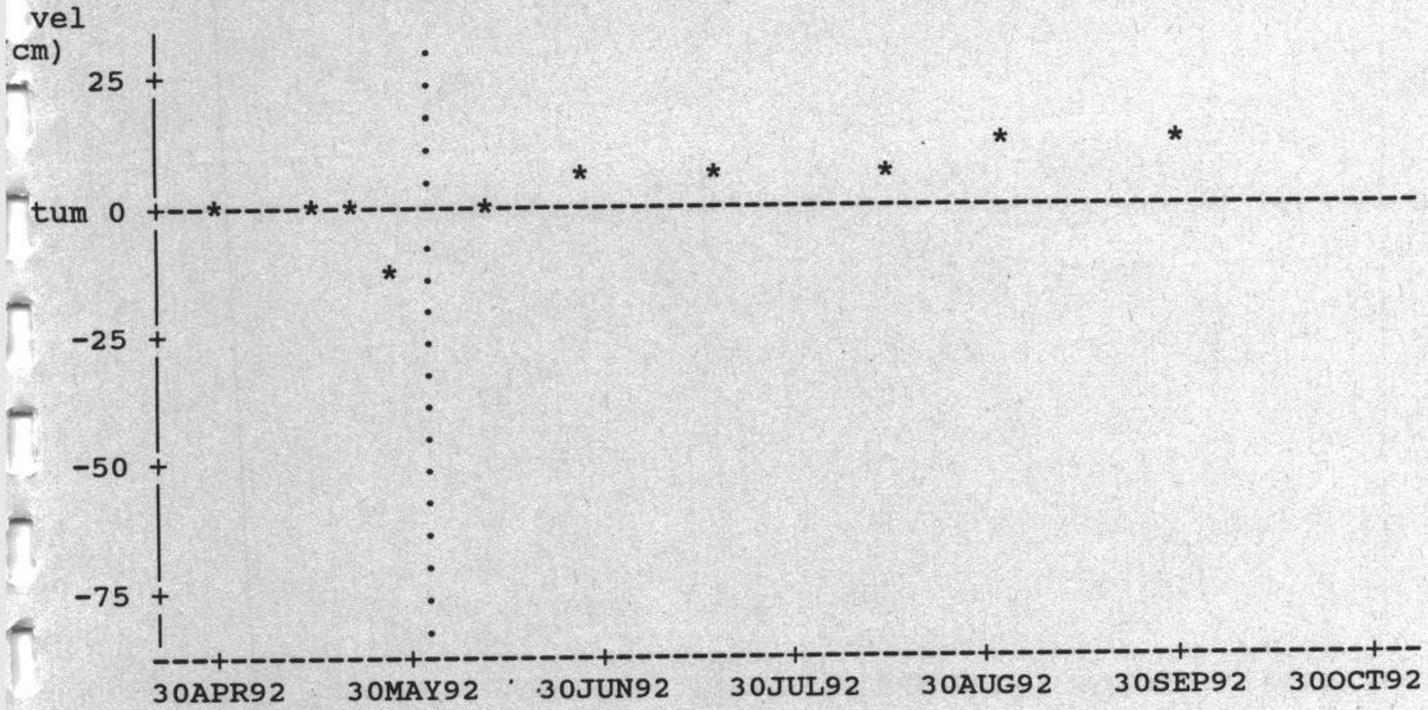
CHANGES IN WATER LEVEL IN POOL 7, LITTLE FEN, DURING 1992



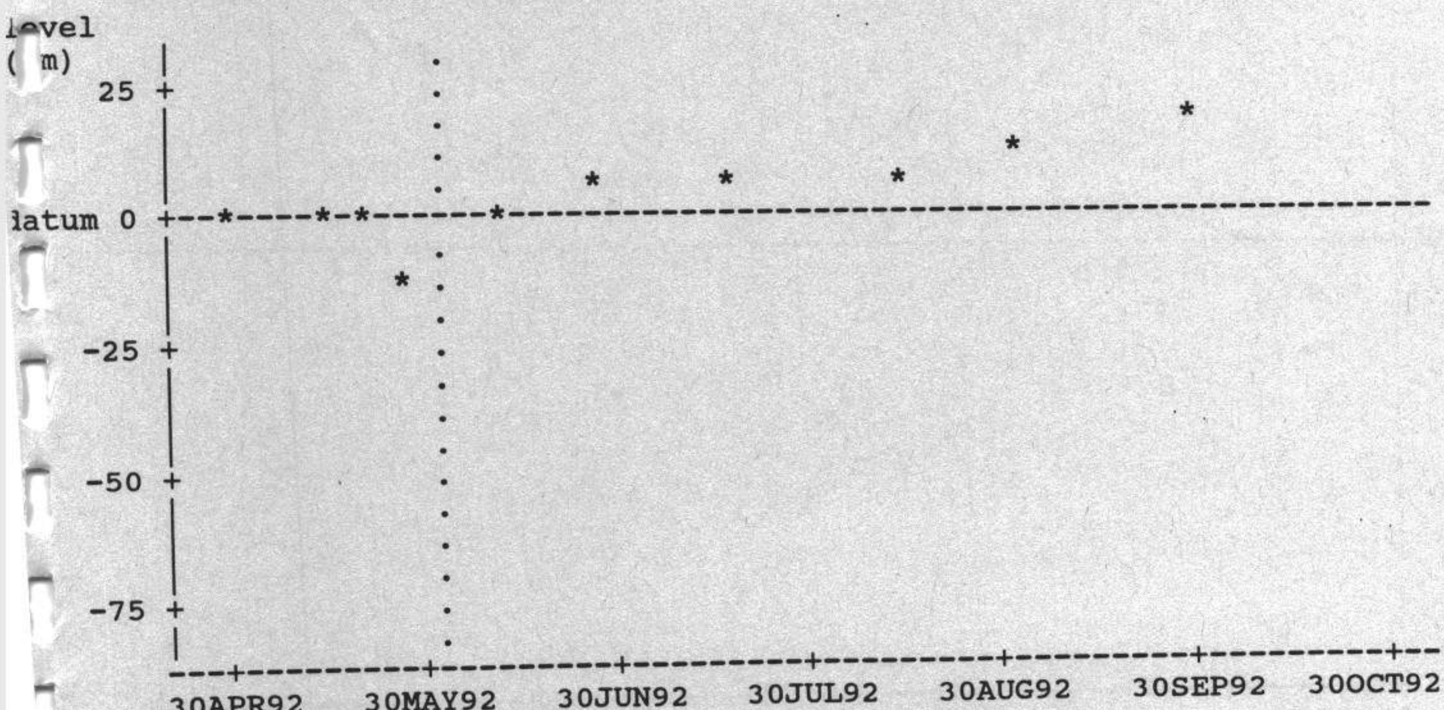
CHANGES IN WATER LEVEL IN POOL 7A, LITTLE FEN, DUING 1992



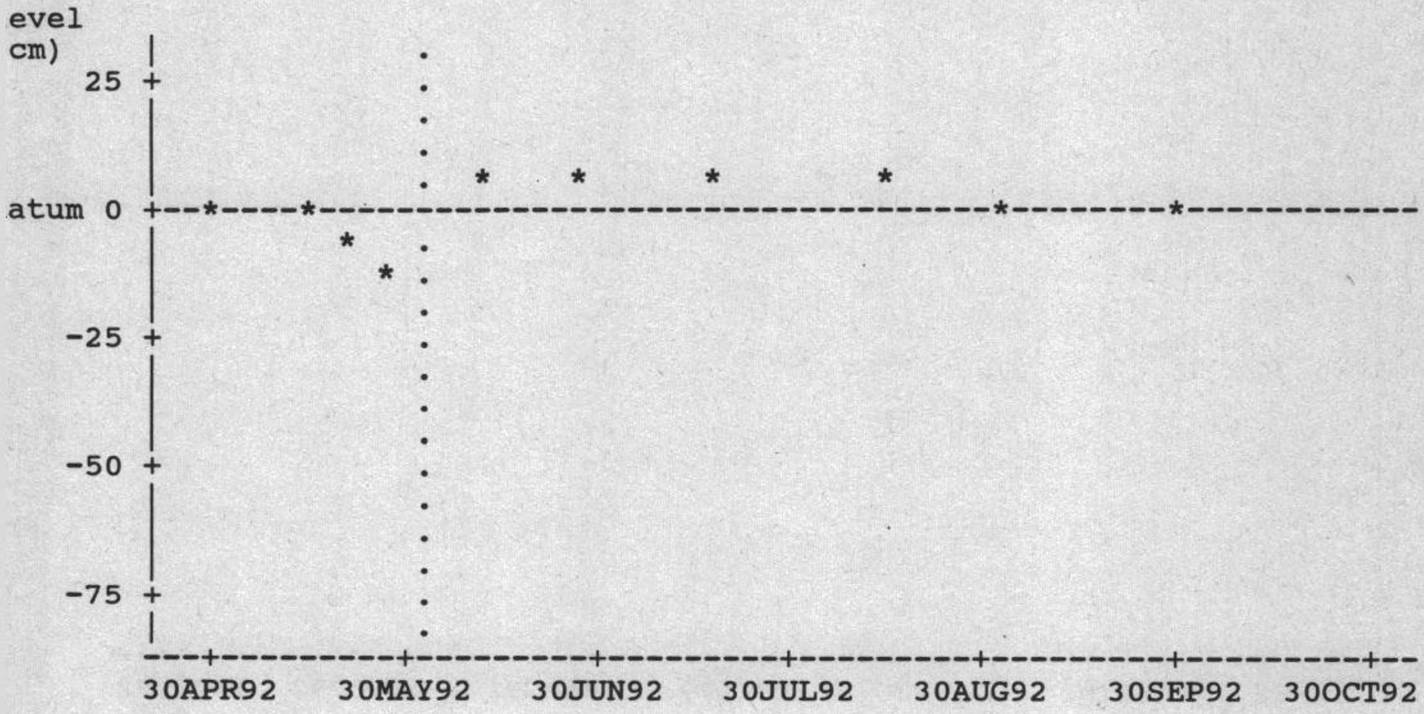
CHANGES IN WATER LEVEL IN POOL 8, LITTLE FEN, DURING 1992



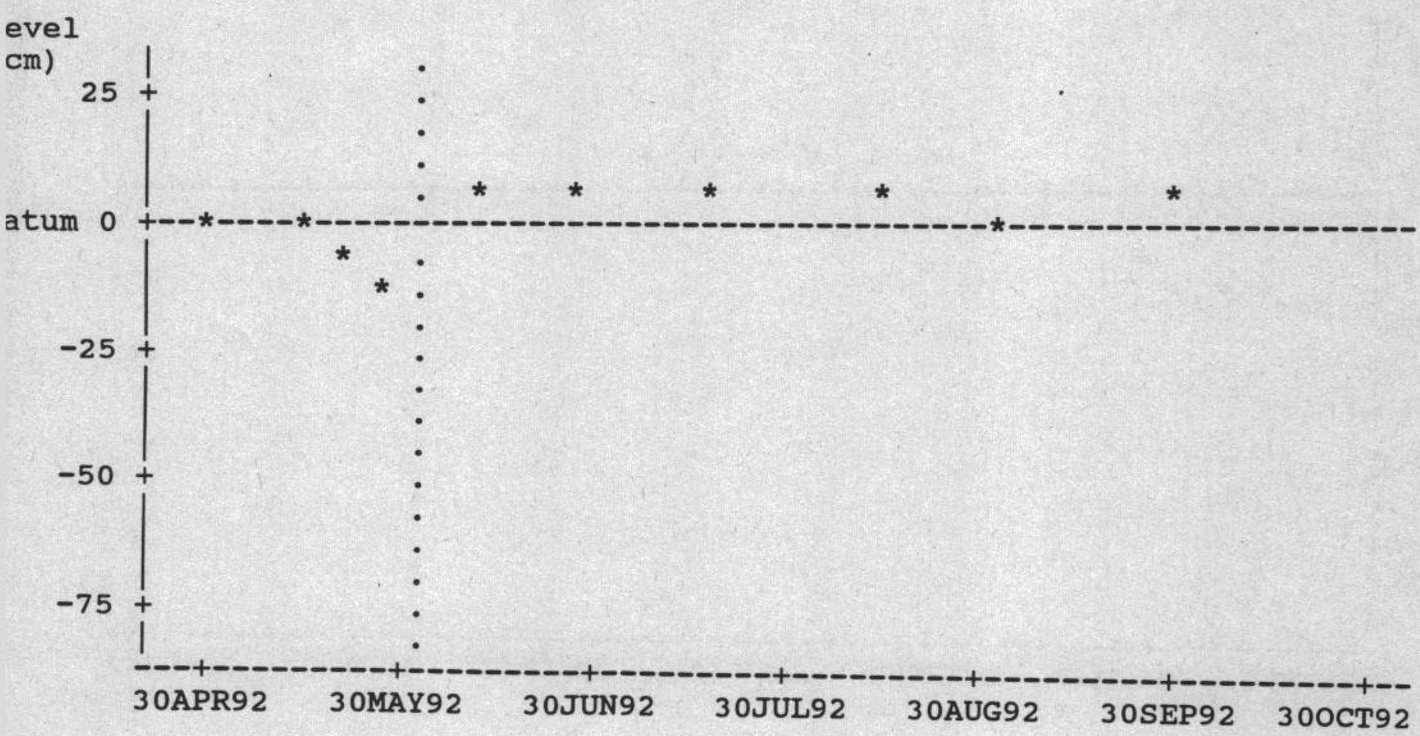
CHANGES IN WATER LEVEL IN POOL 9, LITTLE FEN, DURING 1992



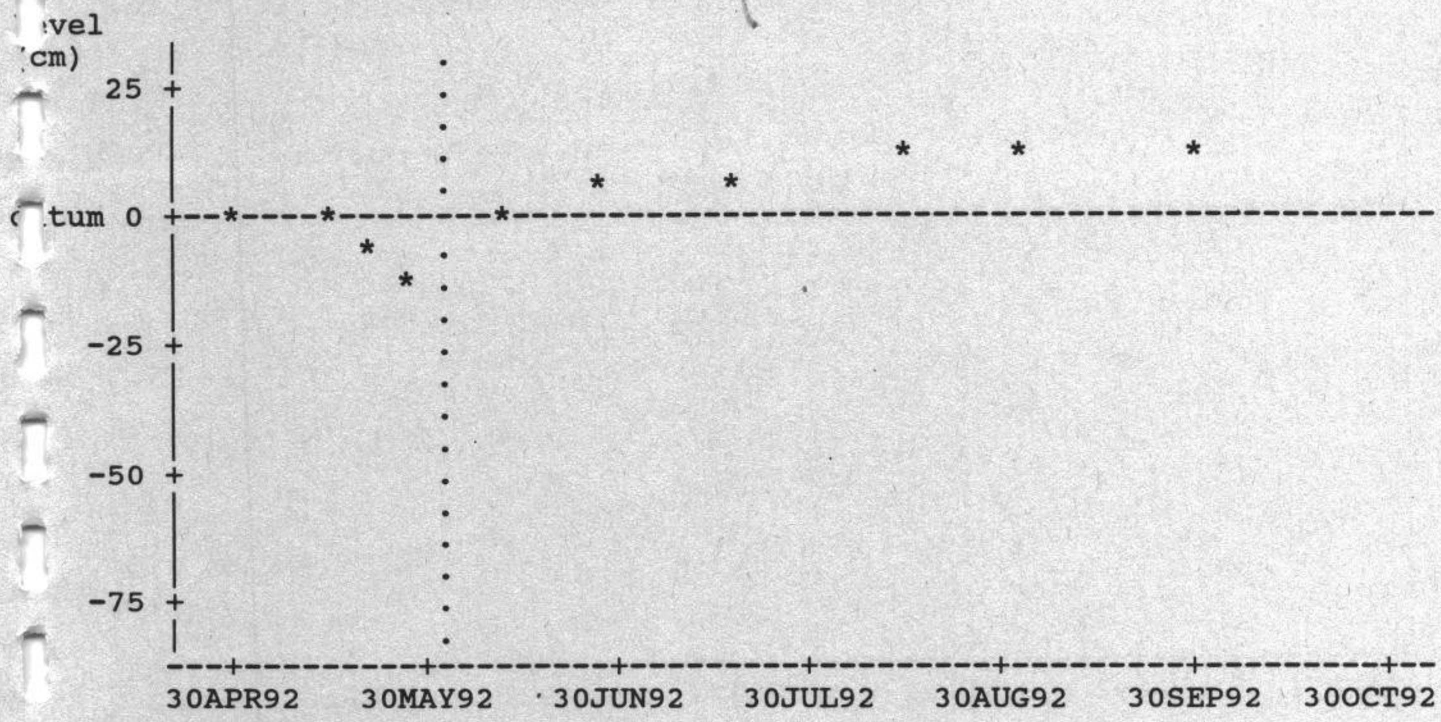
CHANGES IN WATER LEVEL IN POOL 10, LITTLE FEN, DURING 1992



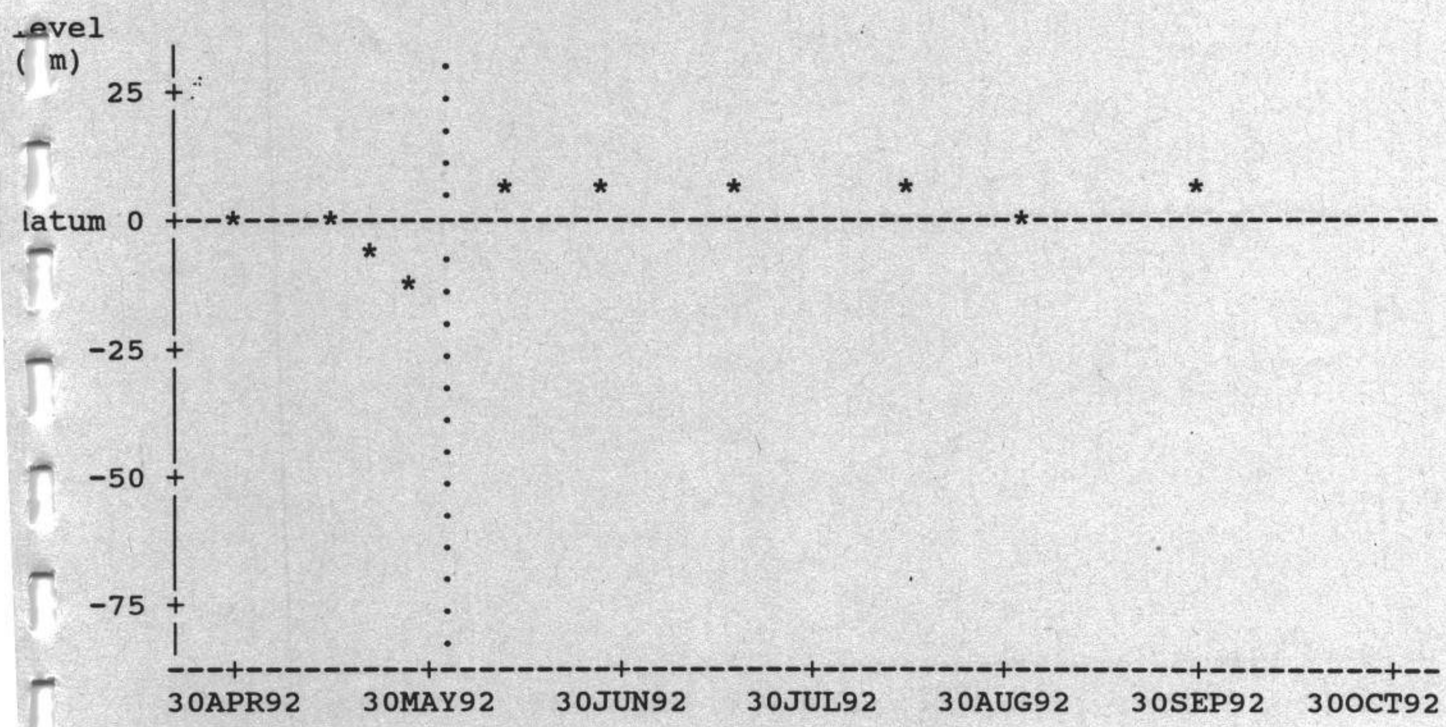
CHANGES IN WATER LEVEL IN POOL 11, LITTLE FEN, DURING 1992



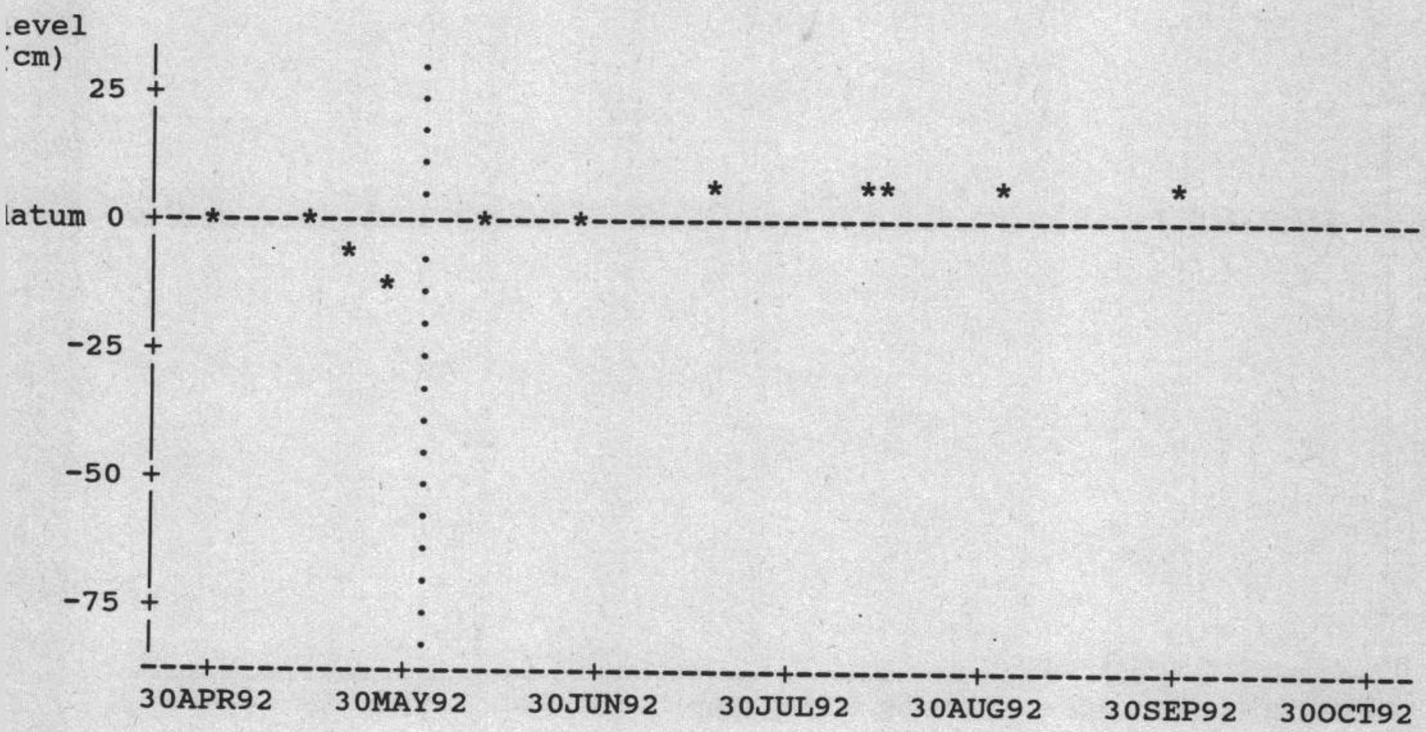
CHANGES IN WATER LEVEL IN POOL 12, LITTLE FEN, DURING 1992



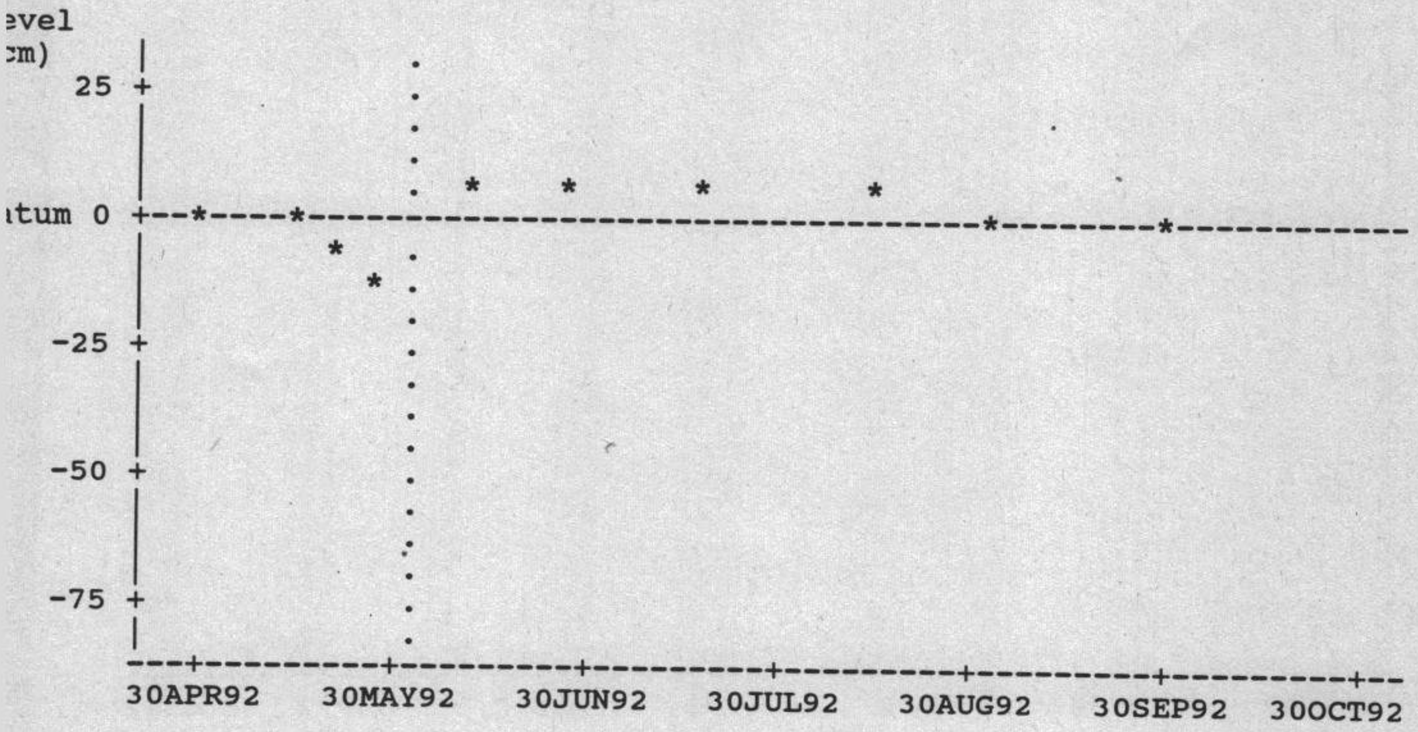
CHANGES IN WATER LEVEL IN POOL 13, LITTLE FEN, DURING 1992



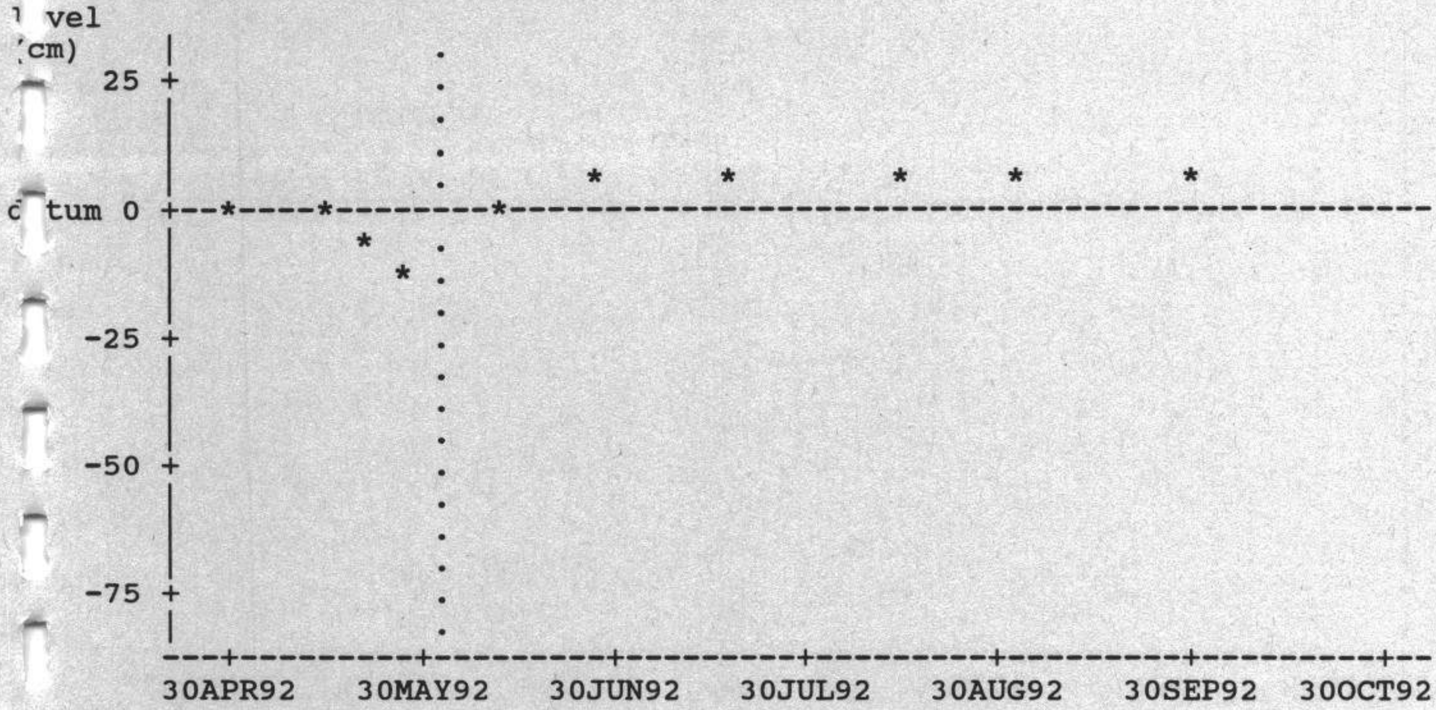
CHANGES IN WATER LEVEL IN POOL 14, LITTLE FEN, DURING 1992



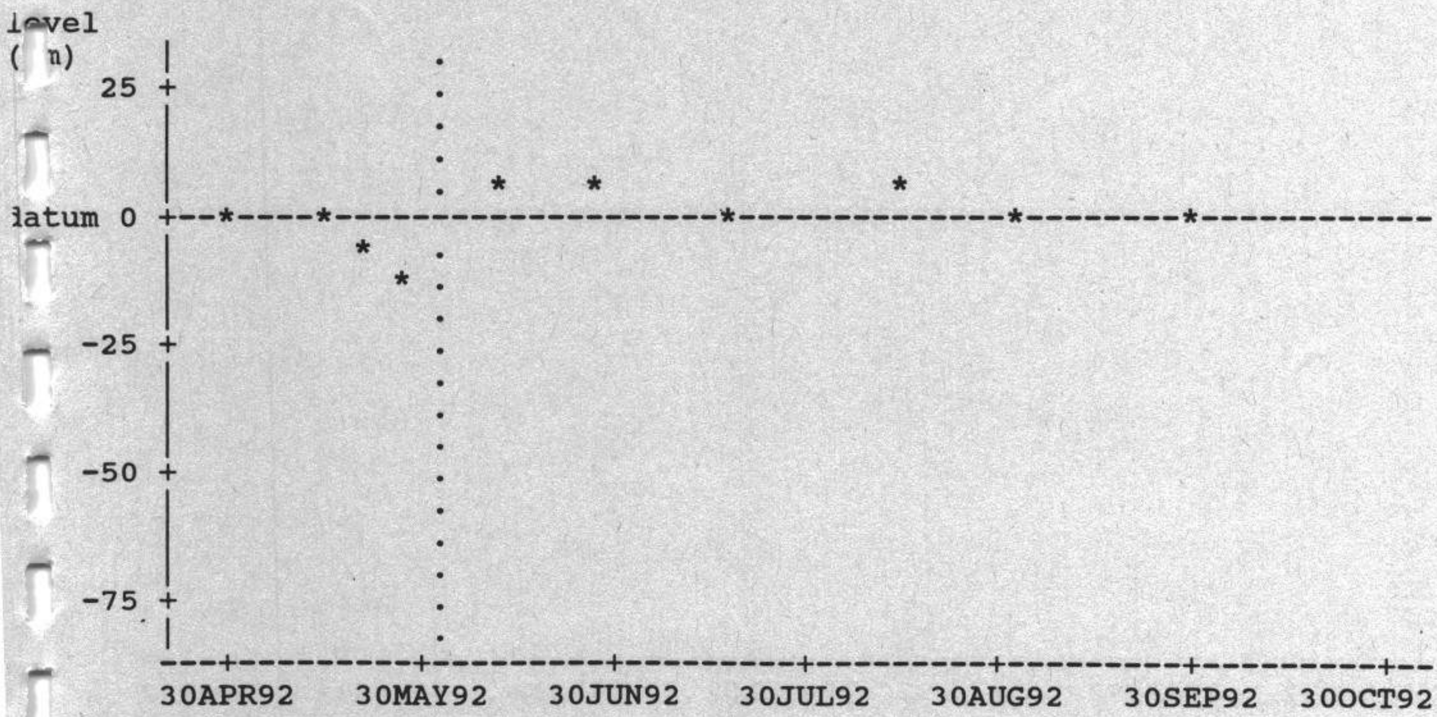
CHANGES IN WATER LEVEL IN POOL 15, LITTLE FEN, DURING 1992



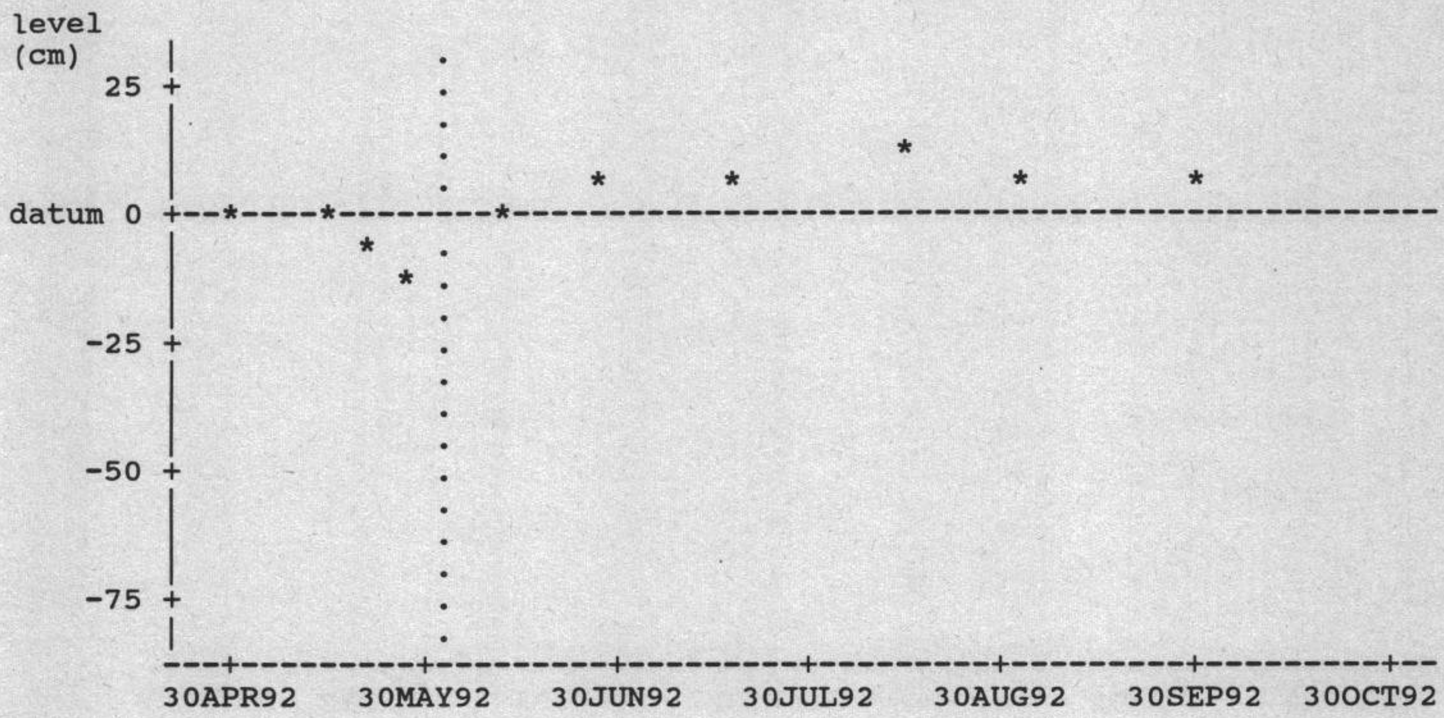
CHANGES IN WATER LEVEL IN POOL 16, LITTLE FEN, DURING 1992



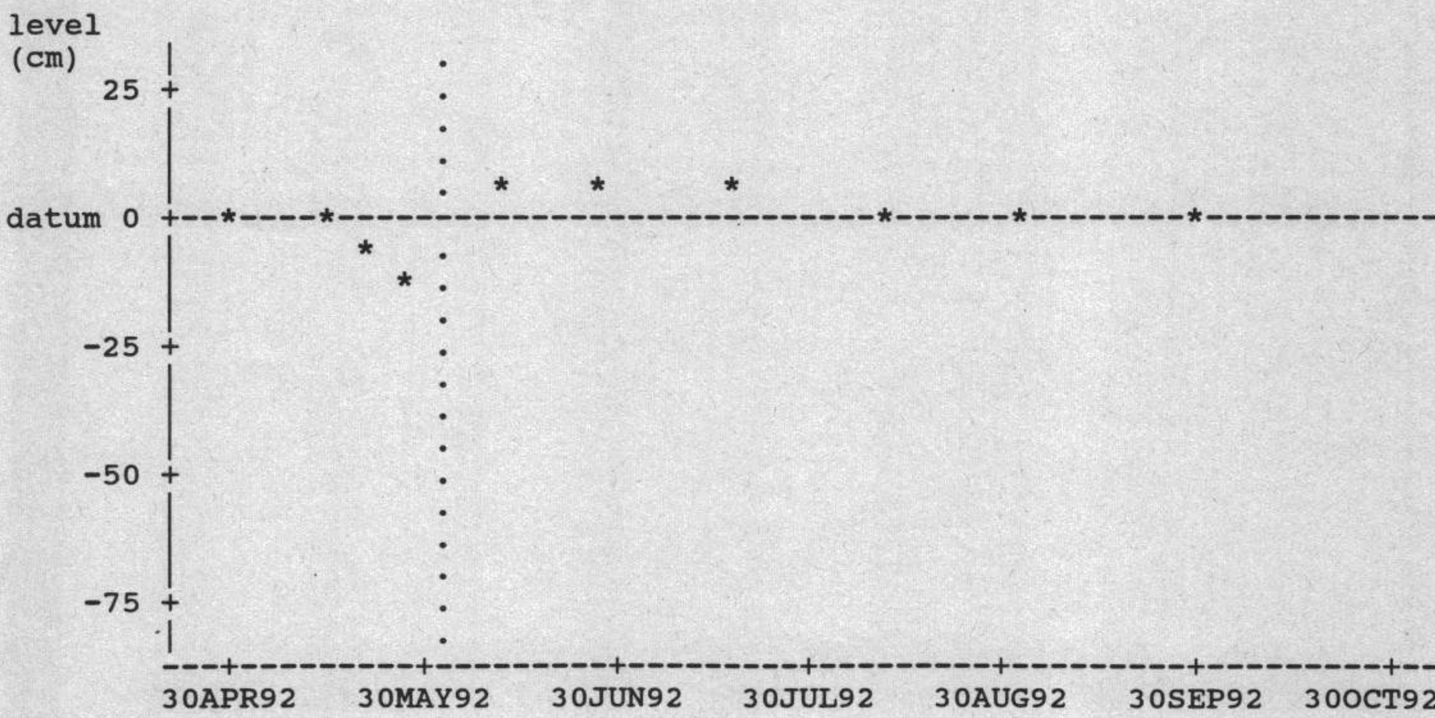
CHANGES IN WATER LEVEL IN POOL 17, LITTLE FEN, DURING 1992



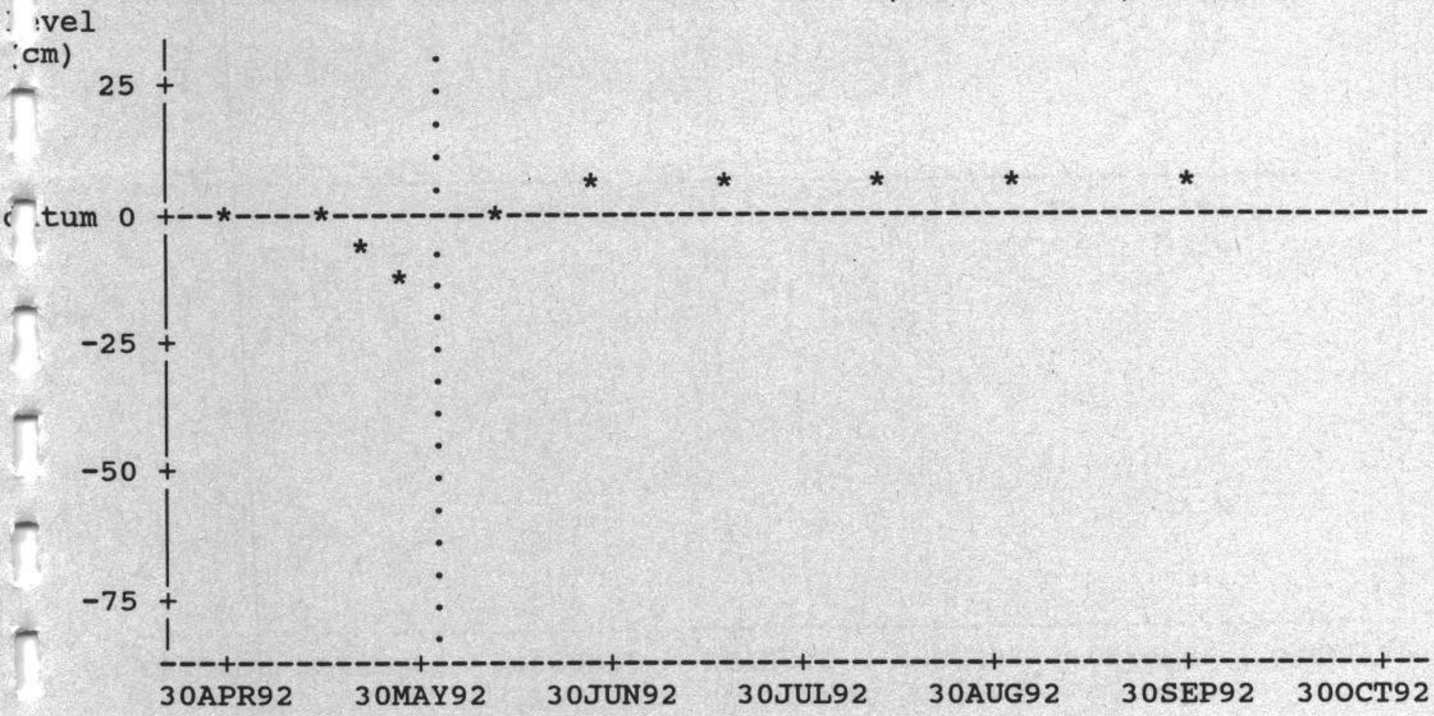
CHANGES IN WATER LEVEL IN POOL 18, LITTLE FEN, DURING 1992



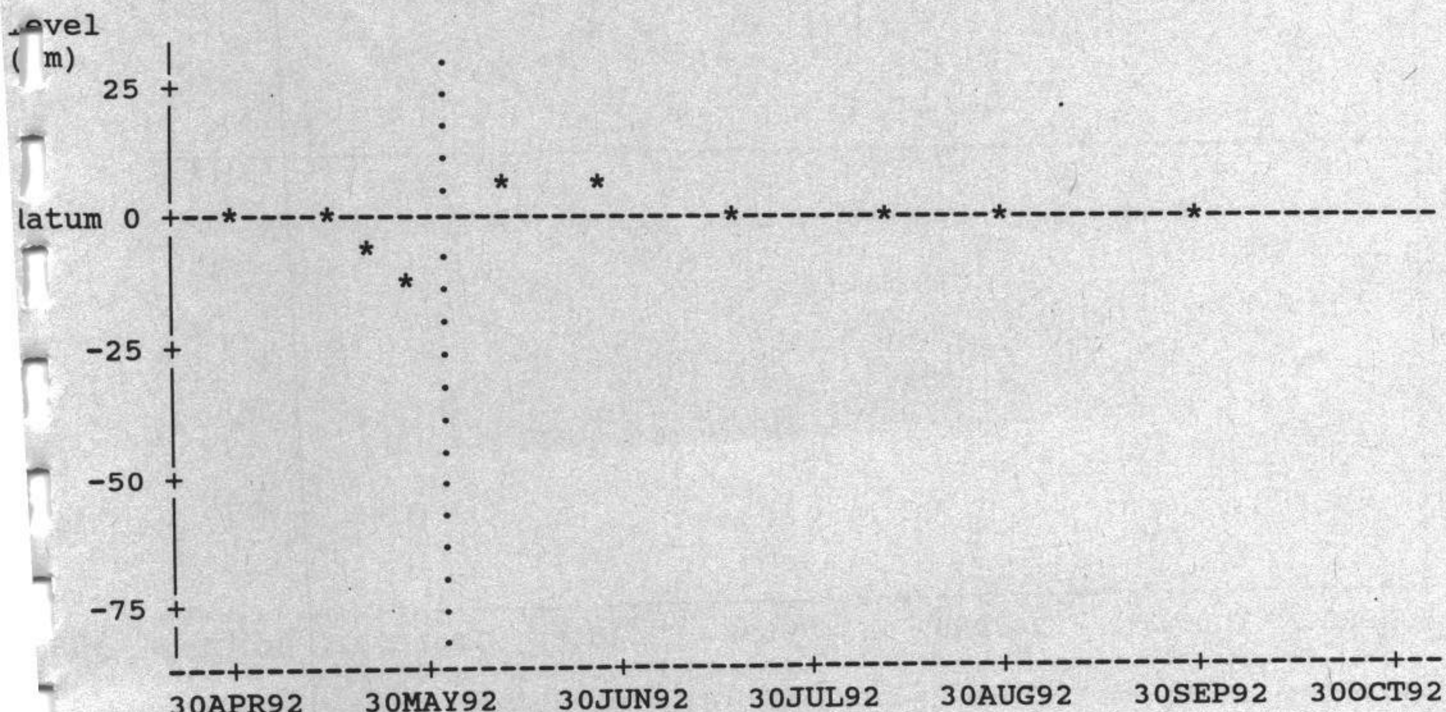
CHANGES IN WATER LEVEL IN POOL 19, LITTLE FEN, DURING 1992



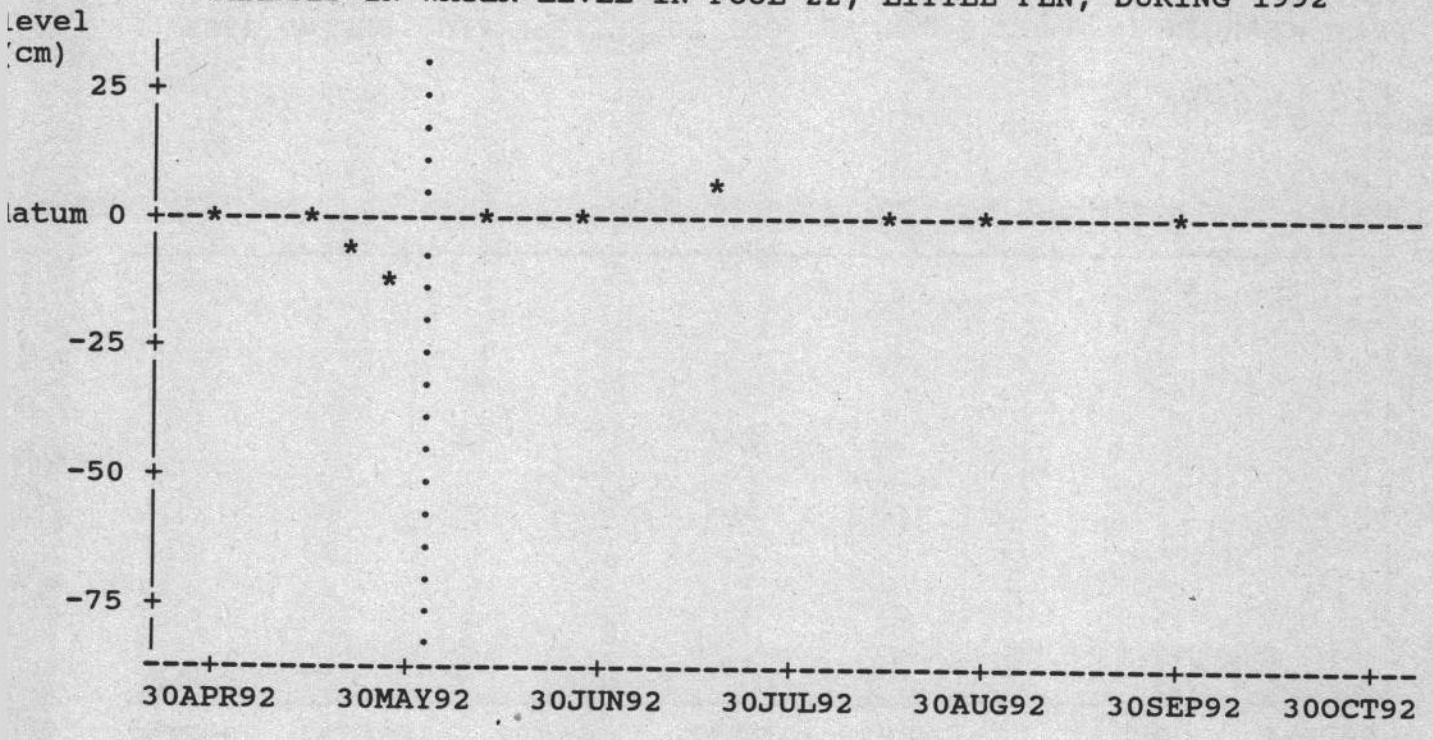
CHANGES IN WATER LEVEL IN POOL 20, LITTLE FEN, DURING 1992



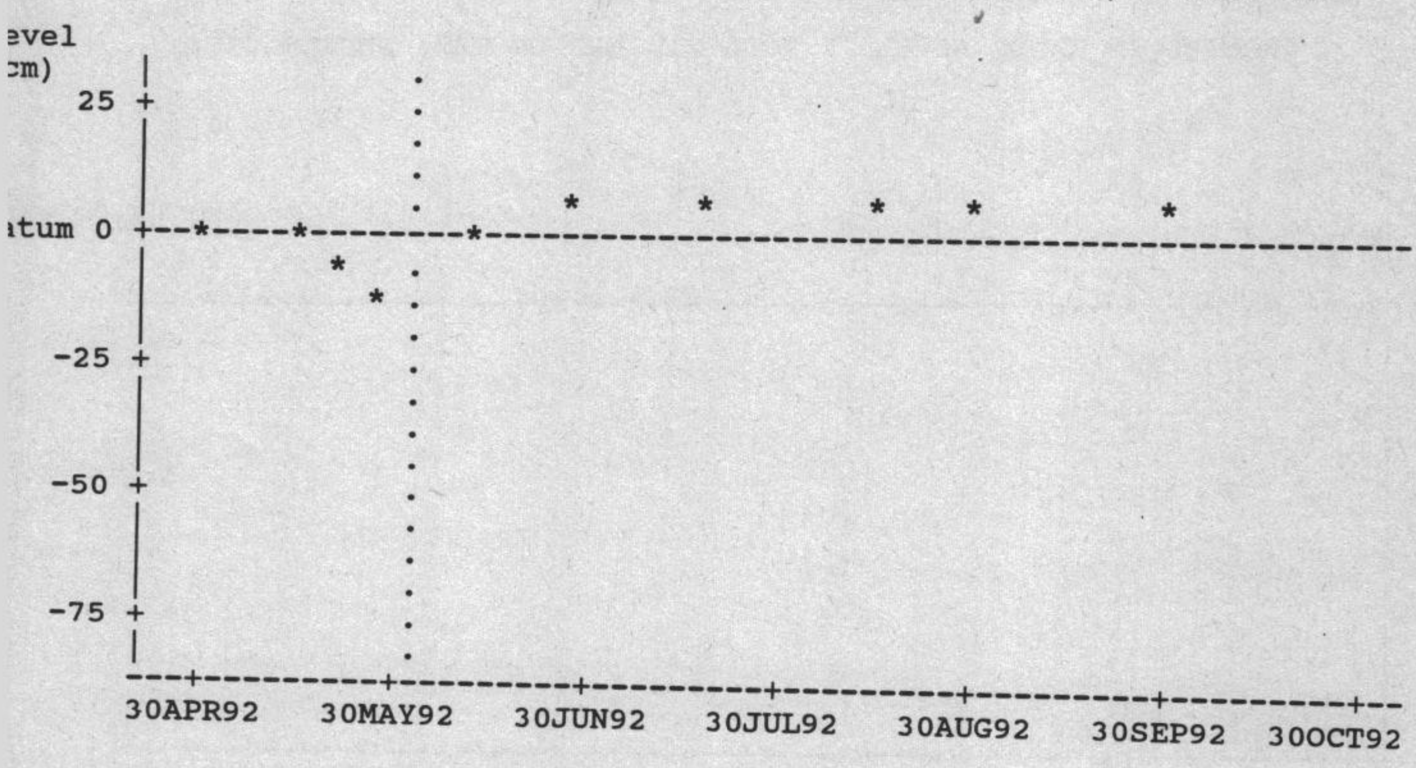
CHANGES IN WATER LEVEL IN POOL 21, LITTLE FEN, DURING 1992



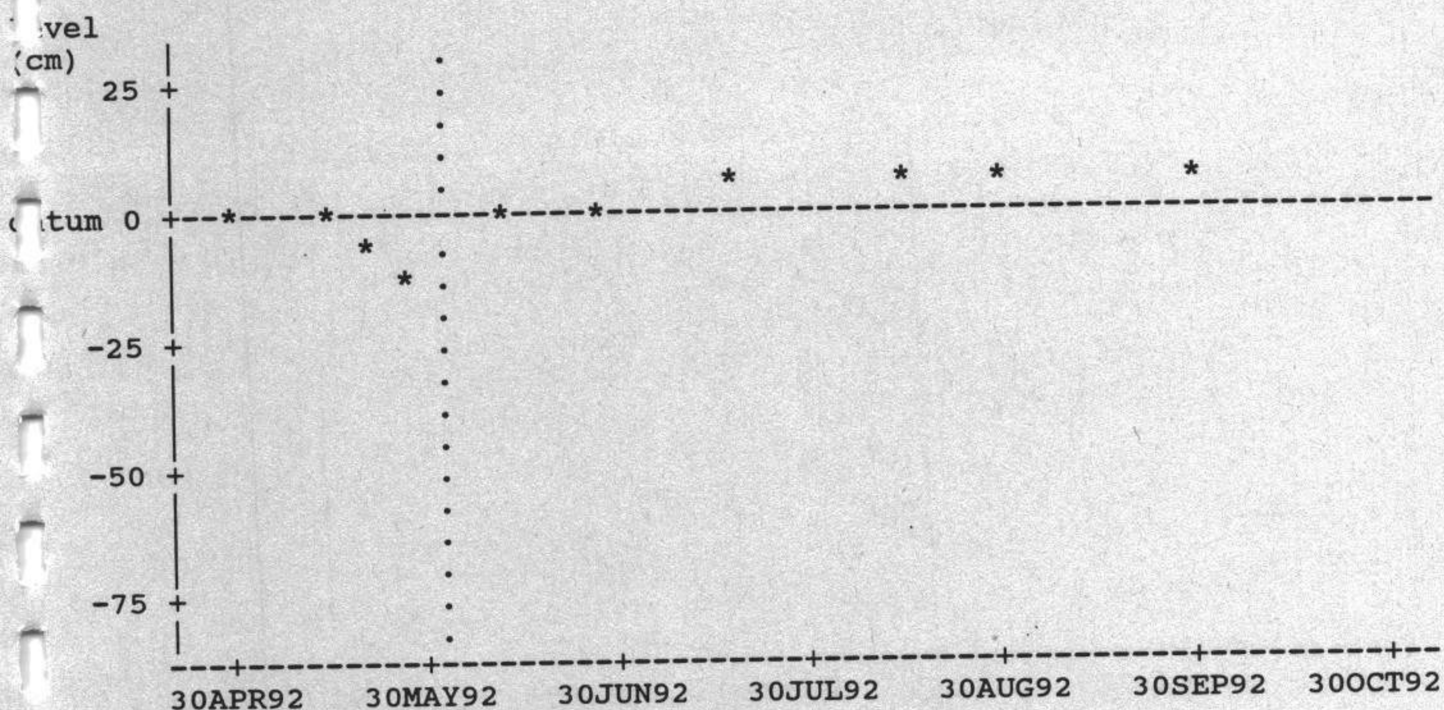
CHANGES IN WATER LEVEL IN POOL 22, LITTLE FEN, DURING 1992



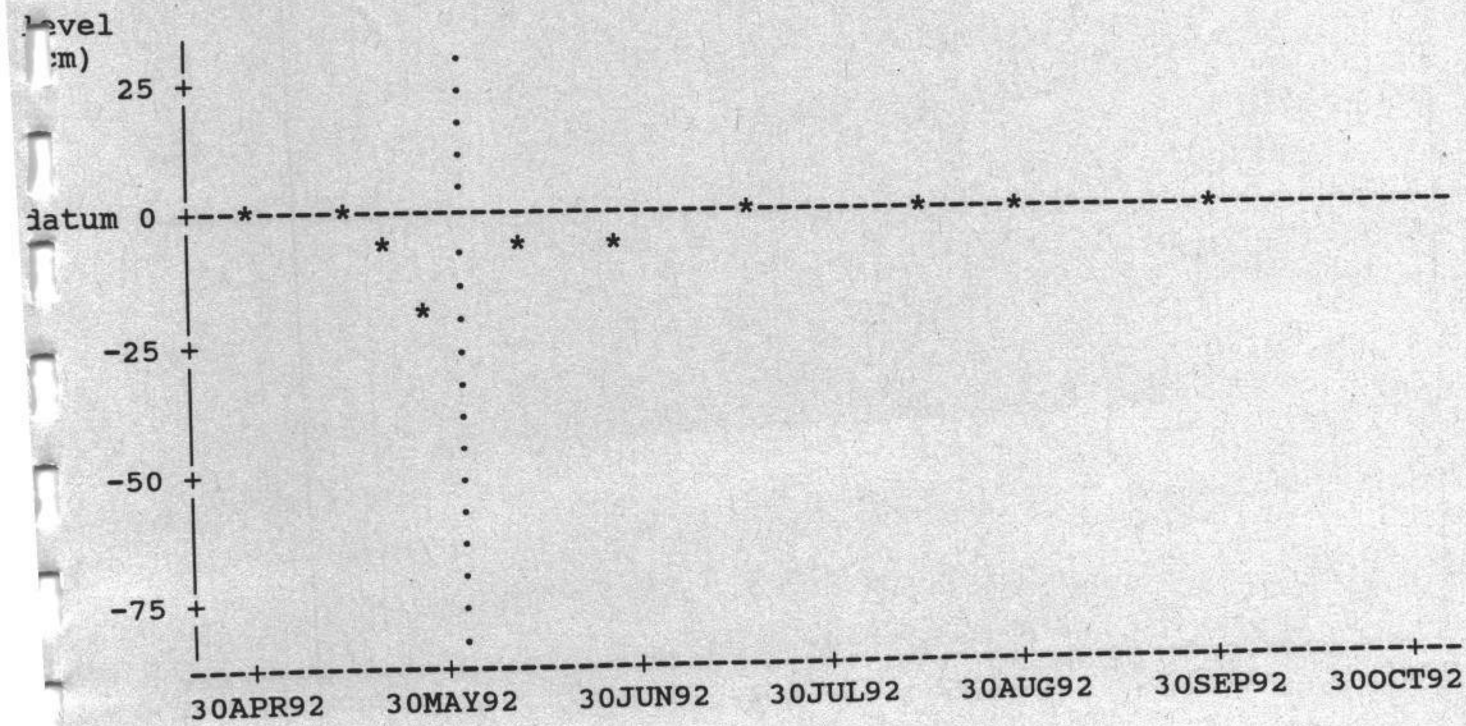
CHANGES IN WATER LEVEL IN POOL 23, LITTLE FEN, DURING 1992



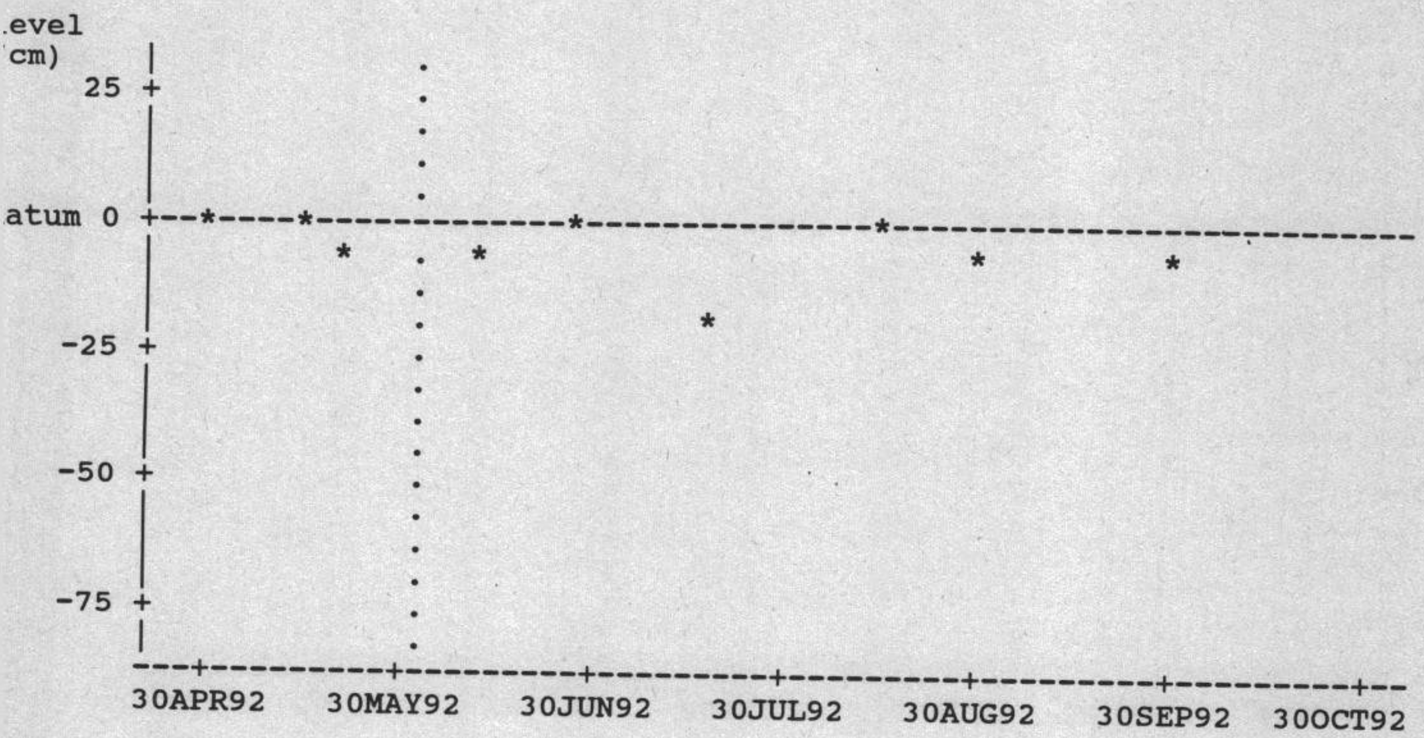
CHANGES IN WATER LEVEL IN POOL 24, LITTLE FEN, DURING 1992



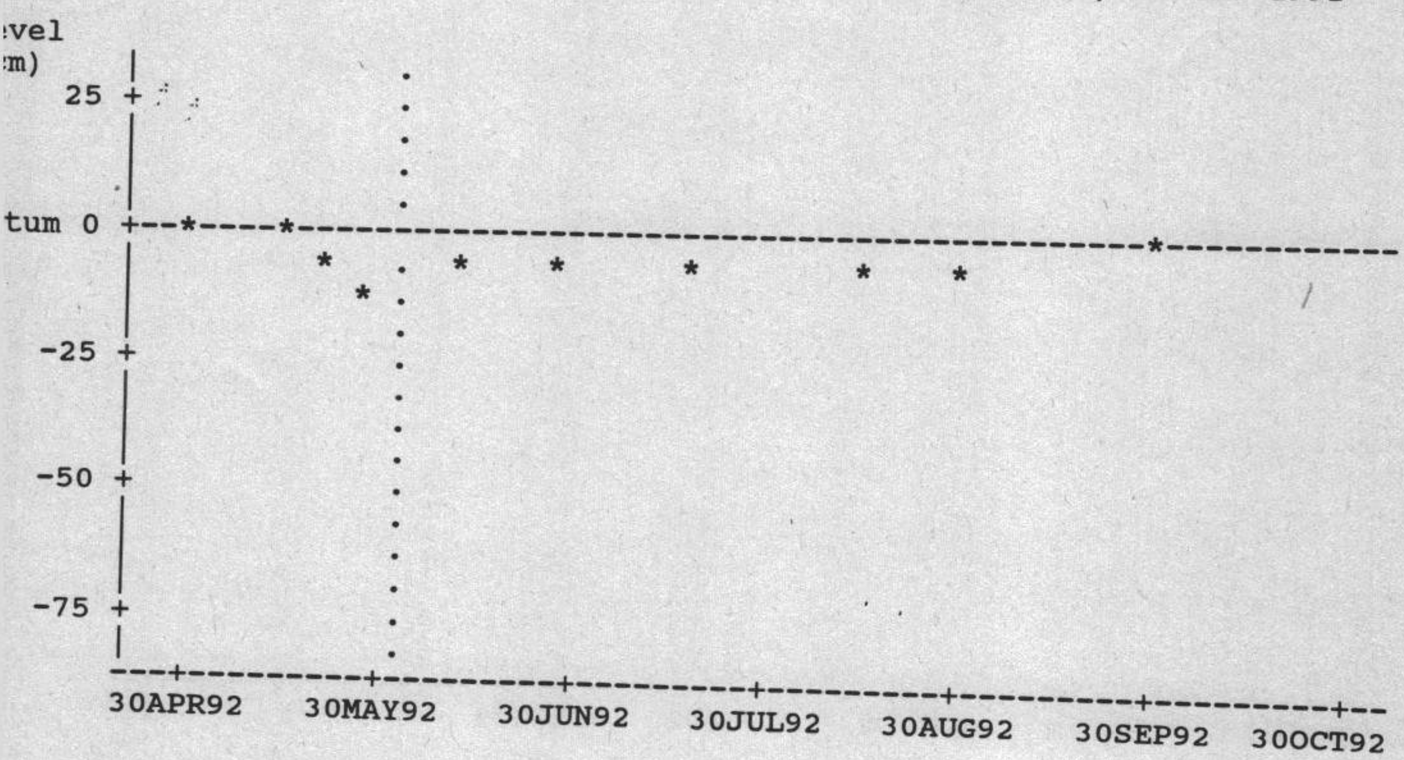
CHANGES IN WATER LEVEL IN POOL 25, LITTLE FEN, DURING 1992



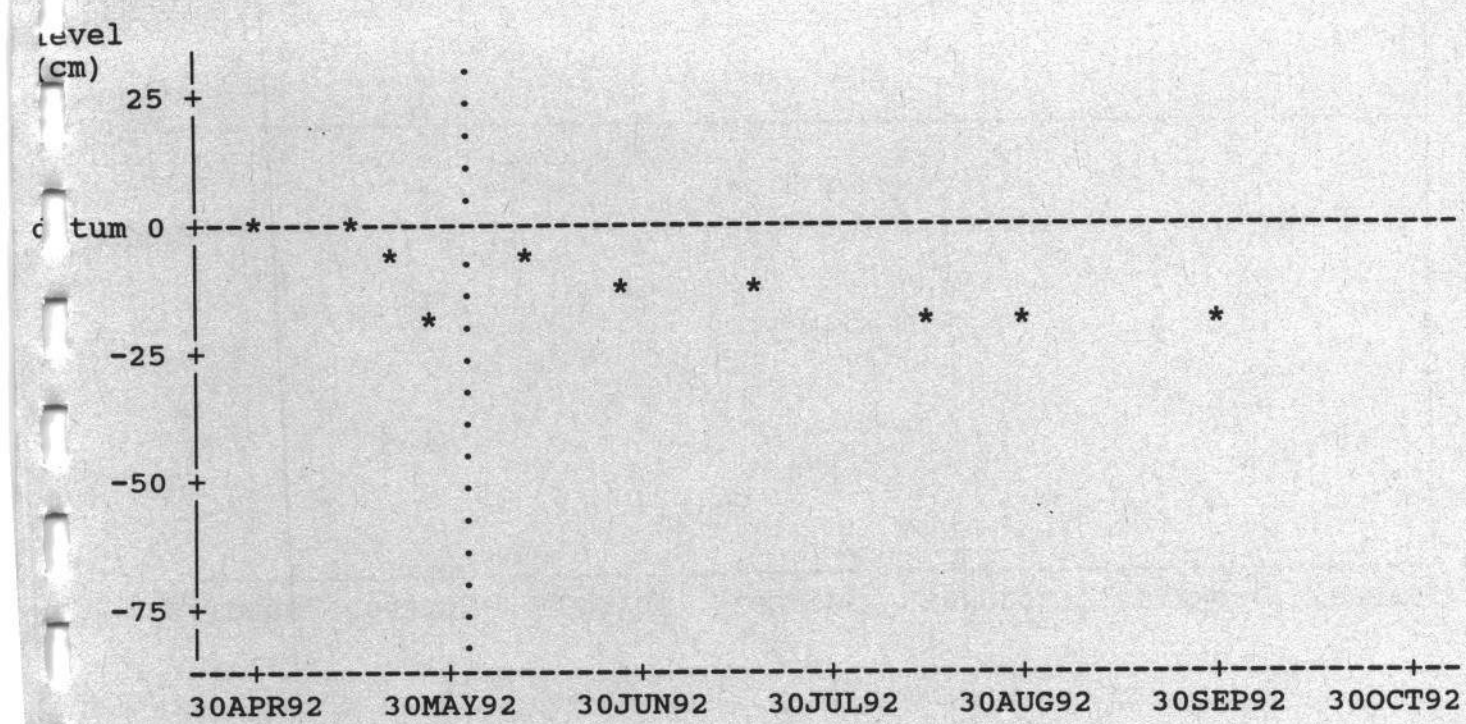
CHANGES IN WATER LEVEL IN POOL 26, LITTLE FEN, DURING 1992



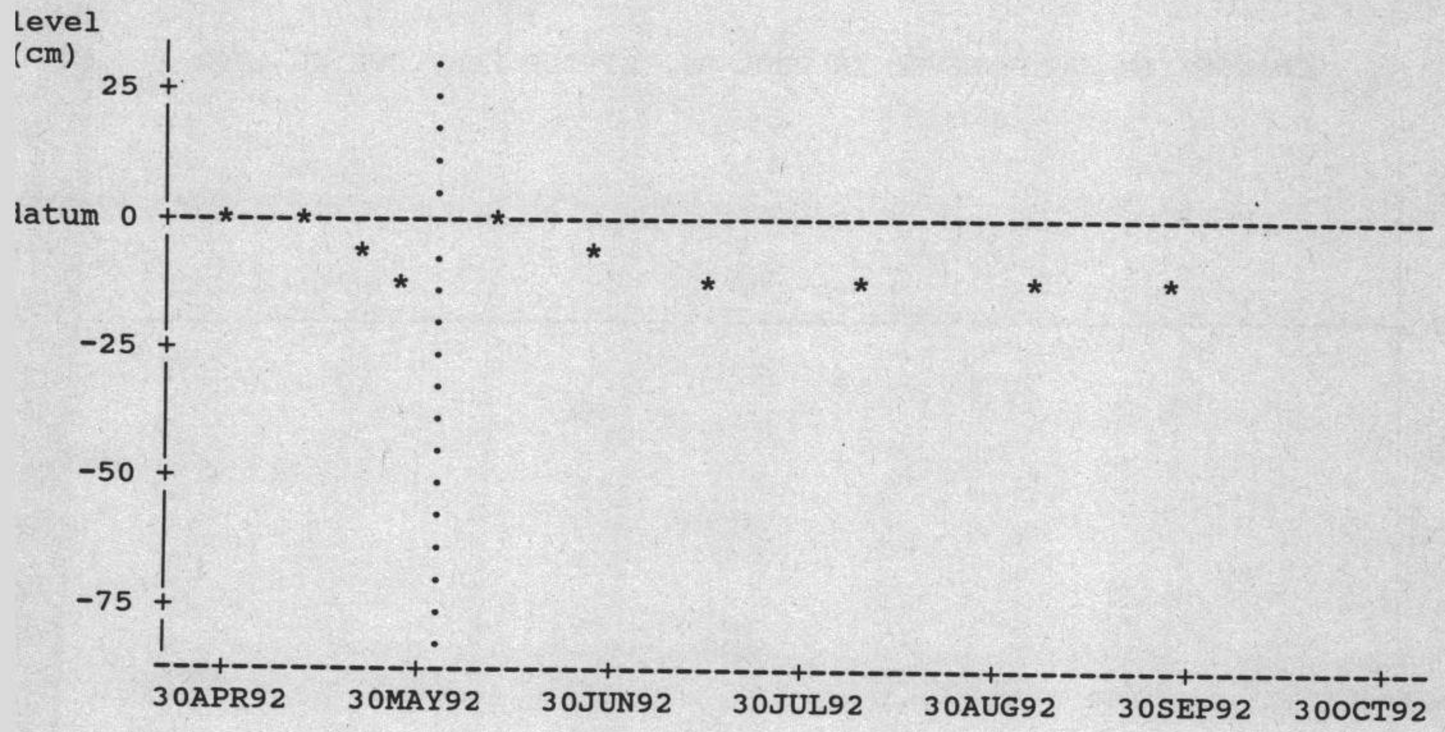
CHANGES IN WATER LEVEL IN POOL 27, LITTLE FEN, DURING 1992



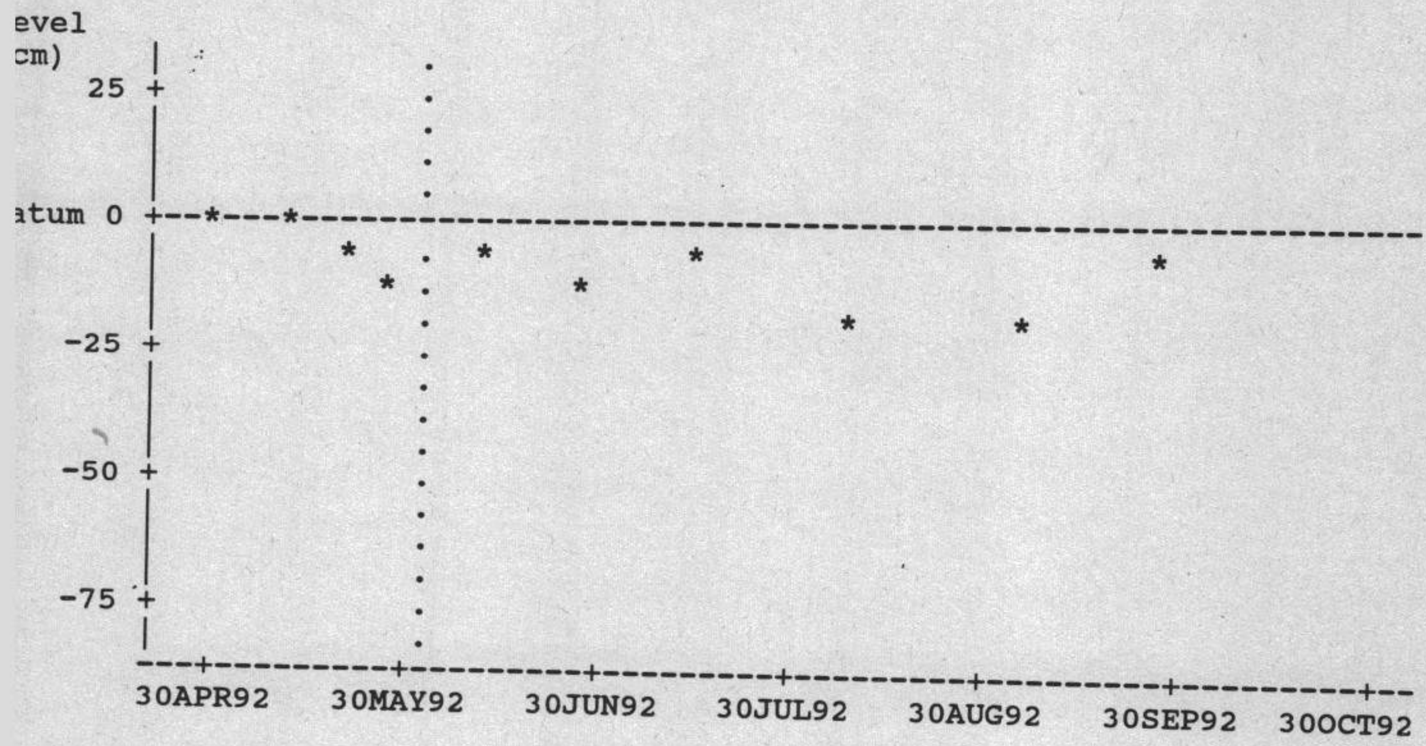
CHANGES IN WATER LEVEL IN POOL 28, LITTLE FEN, DURING 1992



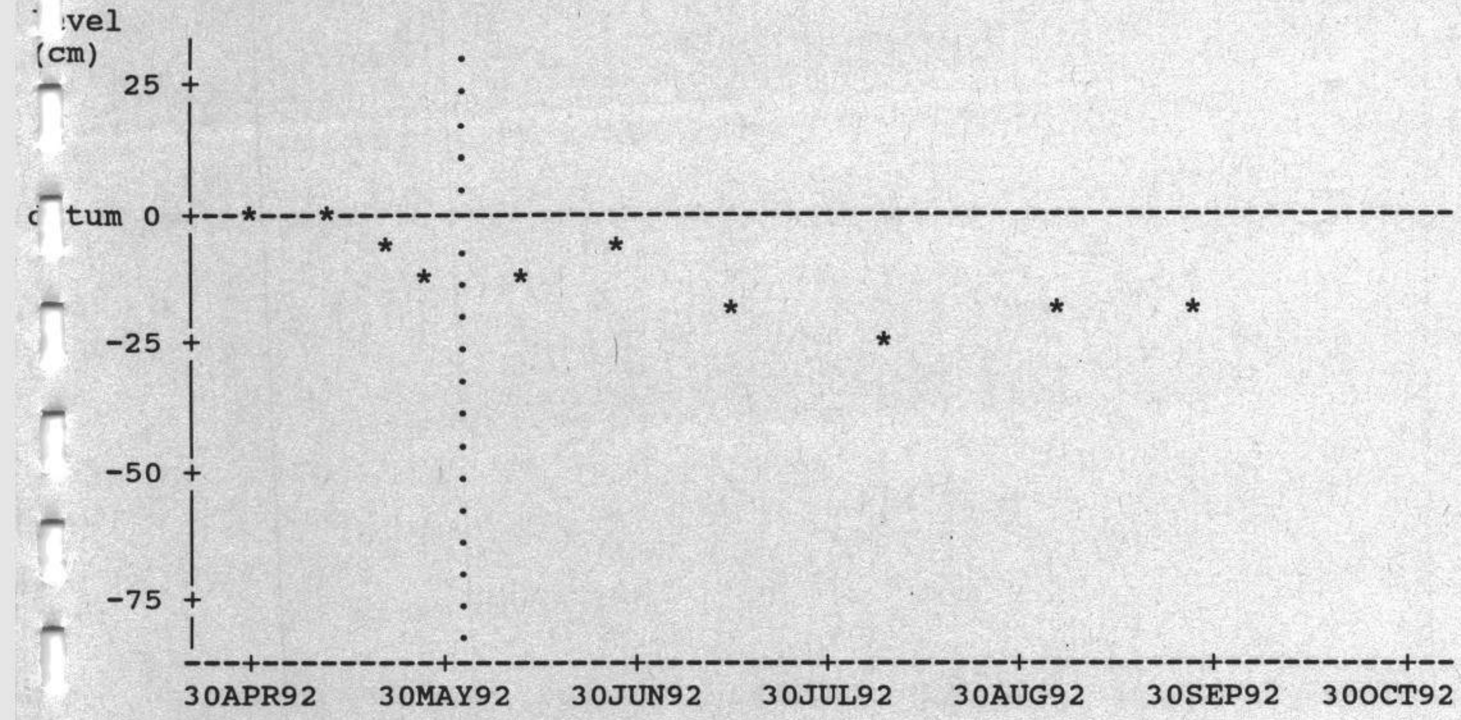
CHANGES IN WATER LEVEL IN POOL 1, MIDDLE FEN, DURING 1992



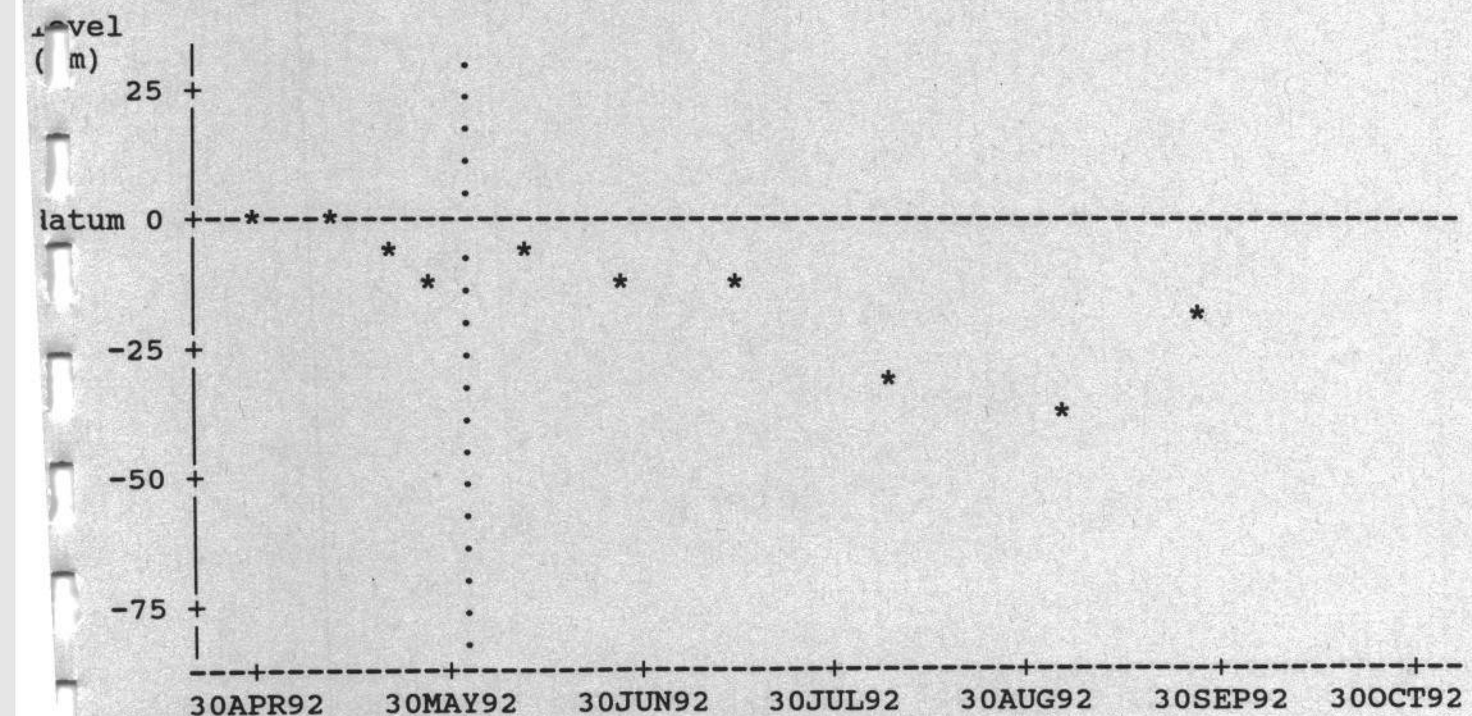
CHANGES IN WATER LEVEL IN POOL 2, MIDDLE FEN, DURING 1992



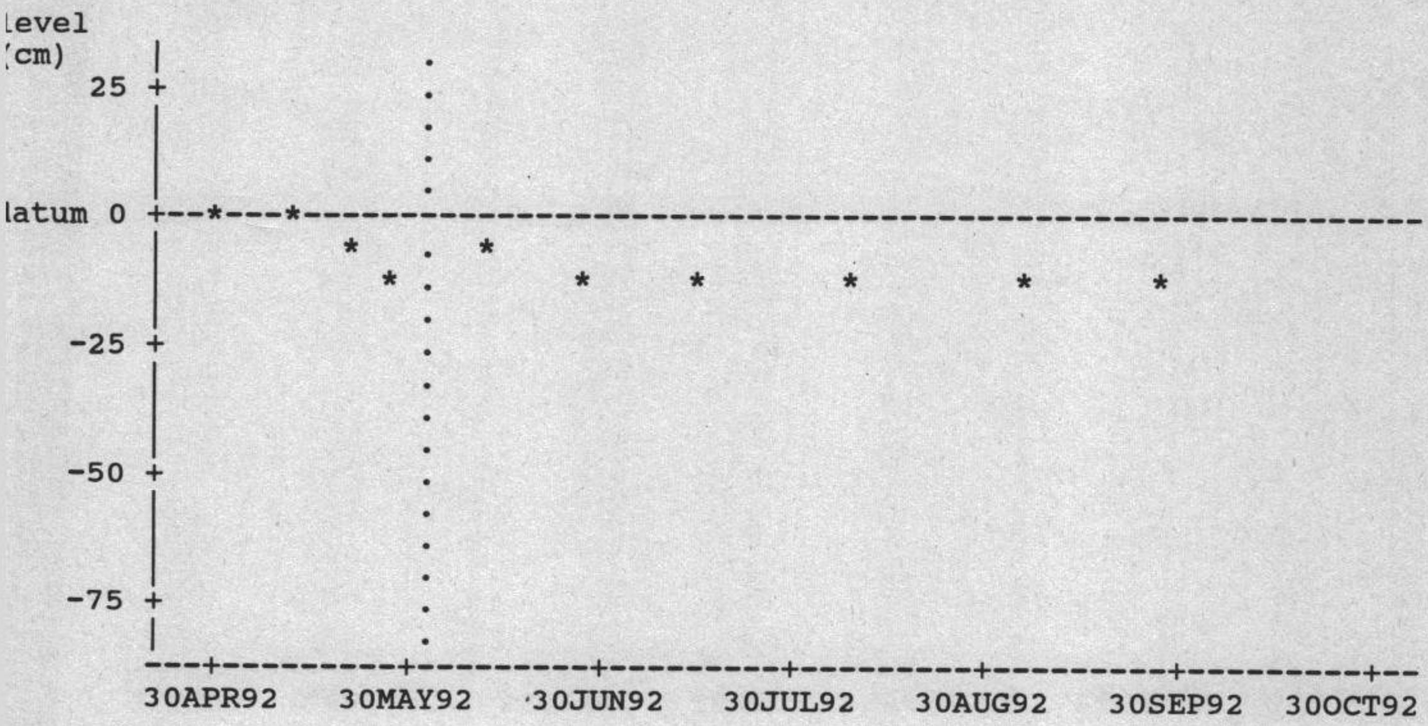
CHANGES IN WATER LEVEL IN POOL 3, MIDDLE FEN, DURING 1992



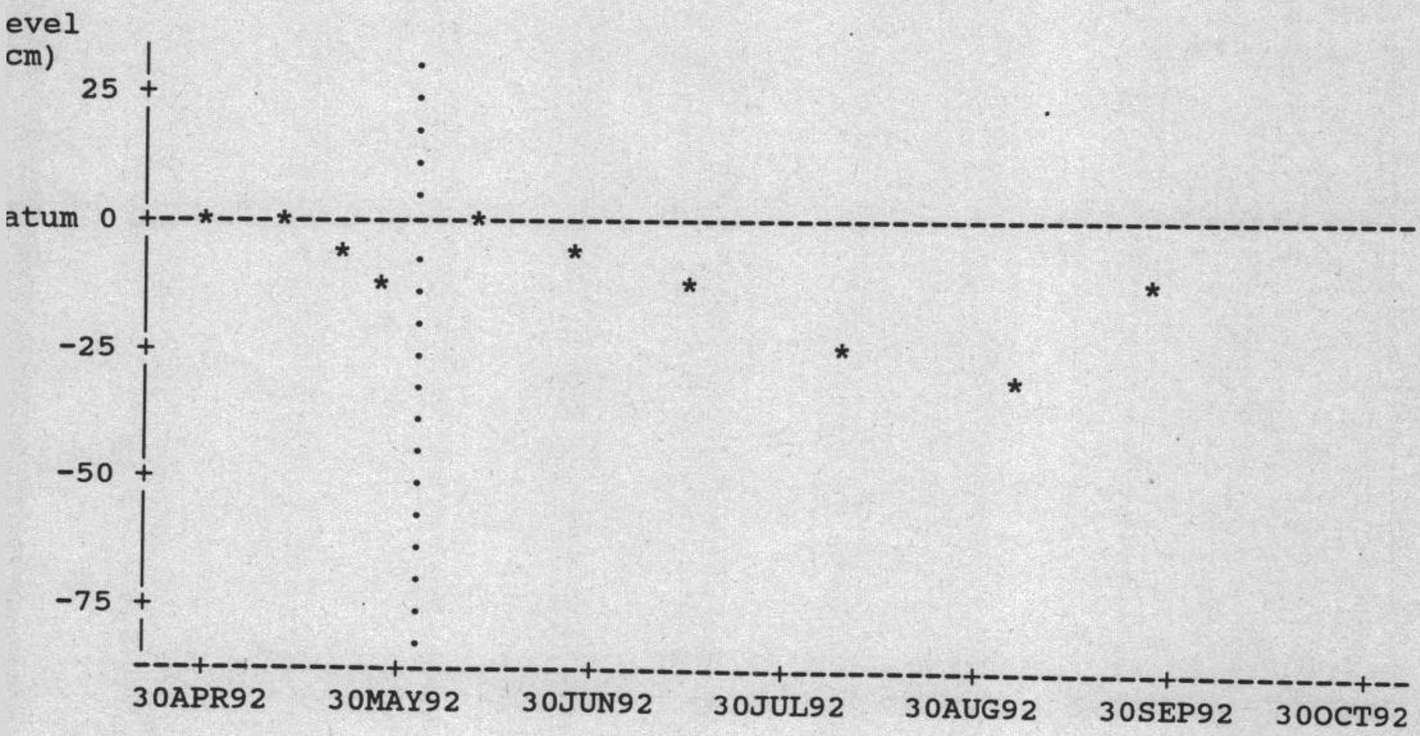
CHANGES IN WATER LEVEL IN POOL 4, MIDDLE FEN, DURING 1992



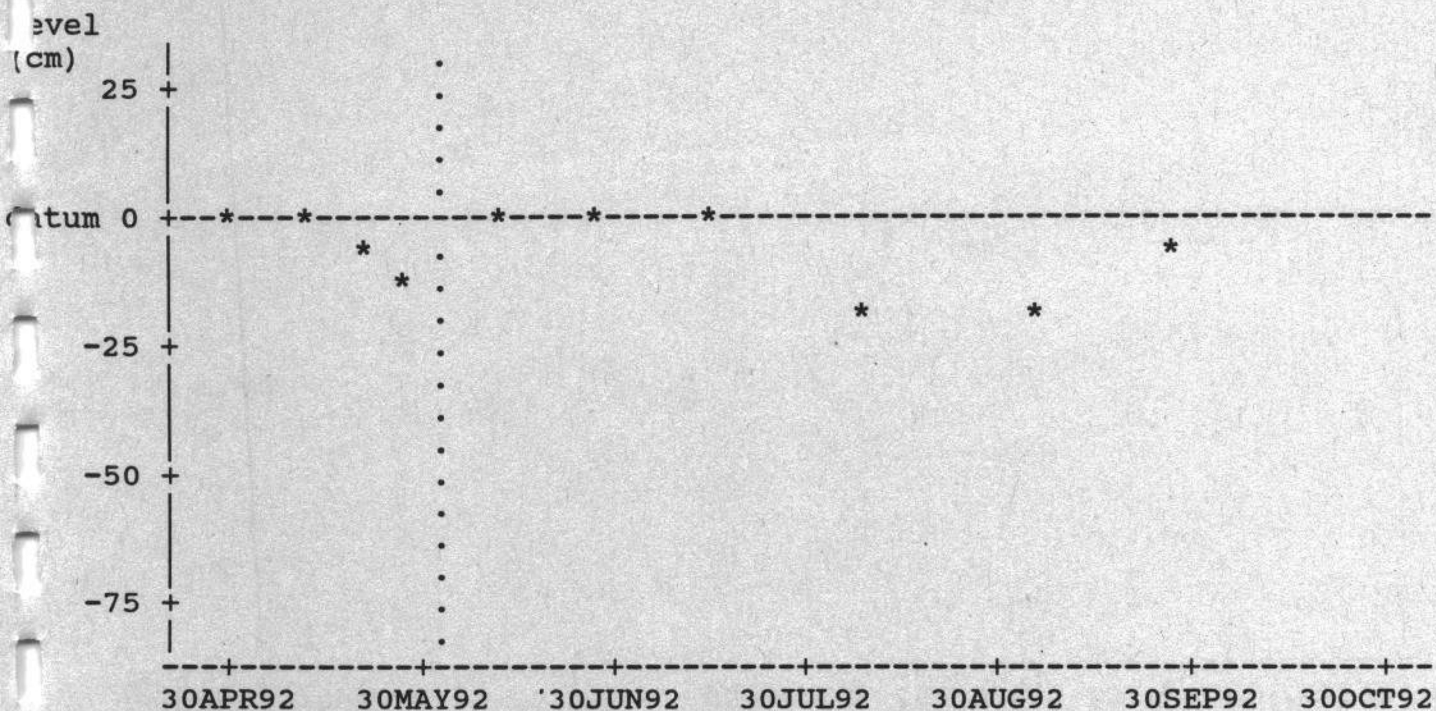
CHANGES IN WATER LEVEL IN POOL 5, MIDDLE FEN, DURING 1992



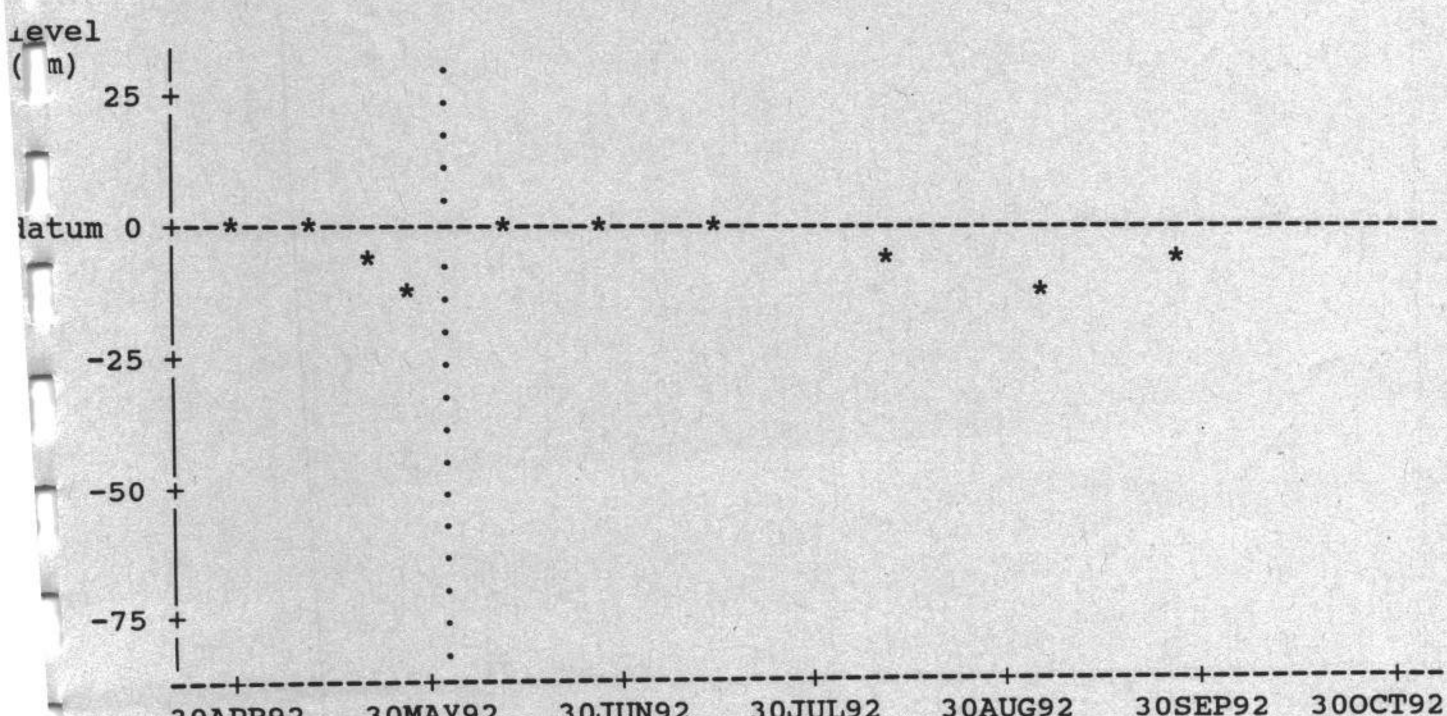
CHANGES IN WATER LEVEL IN POOL 6, MIDDLE FEN, DURING 1992



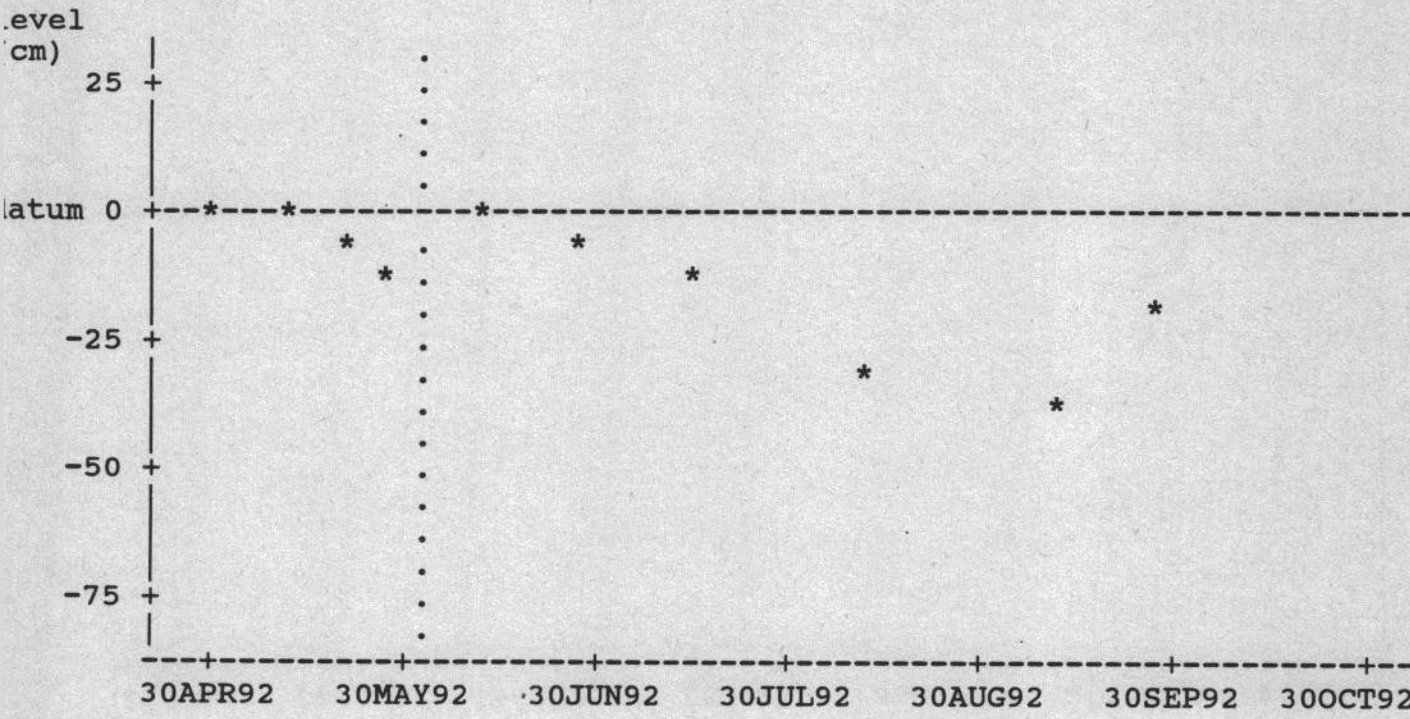
CHANGES IN WATER LEVEL IN POOL 7, MIDDLE FEN, DURING 1992



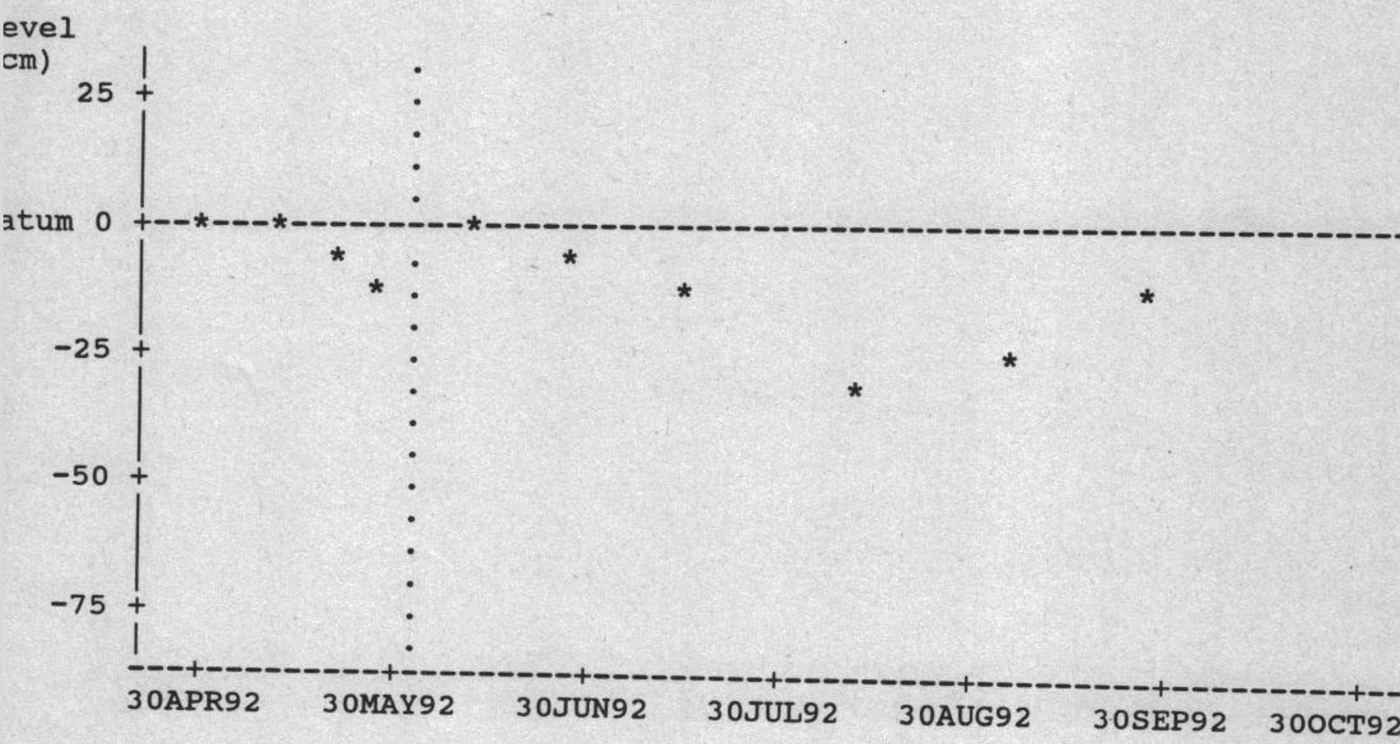
CHANGES IN WATER LEVEL IN POOL 7A, MIDDLE FEN, DURING 1992



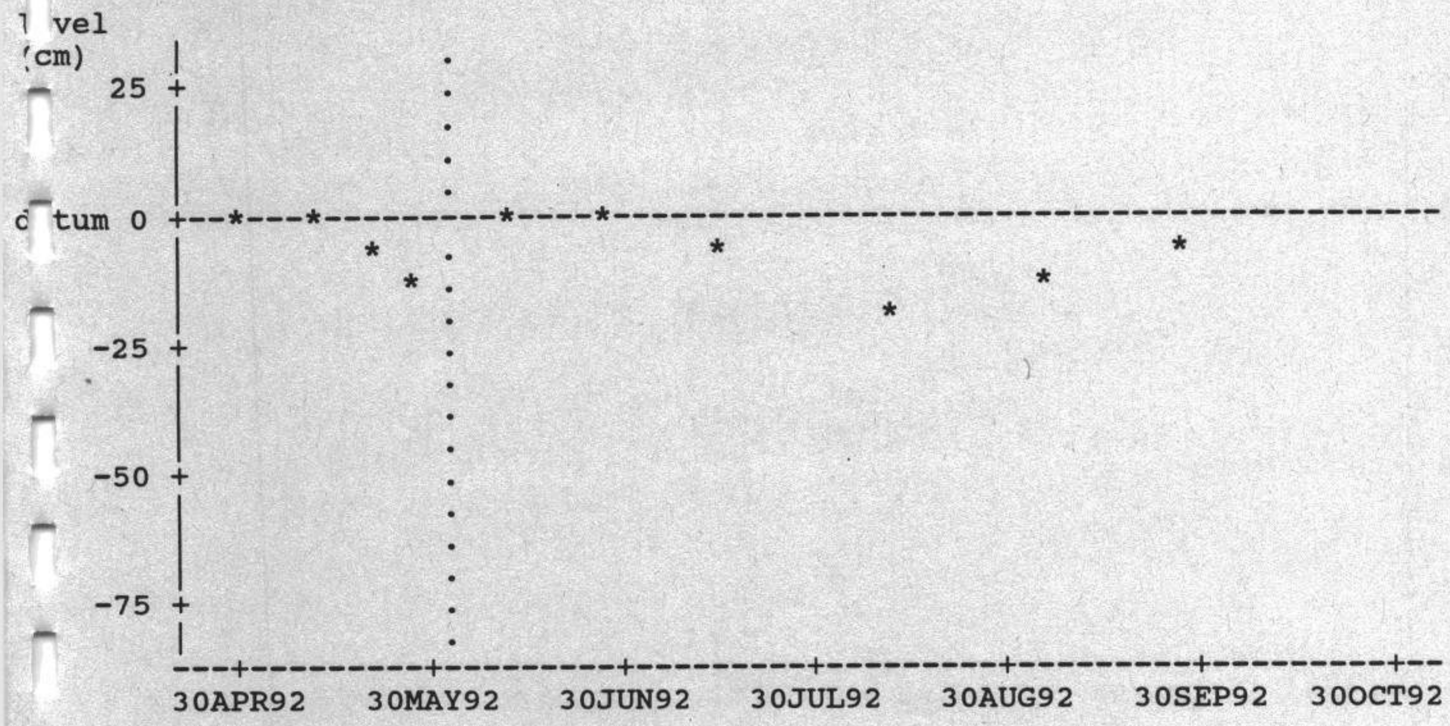
CHANGES IN WATER LEVEL IN POOL 8, MIDDLE FEN, DURING 1992



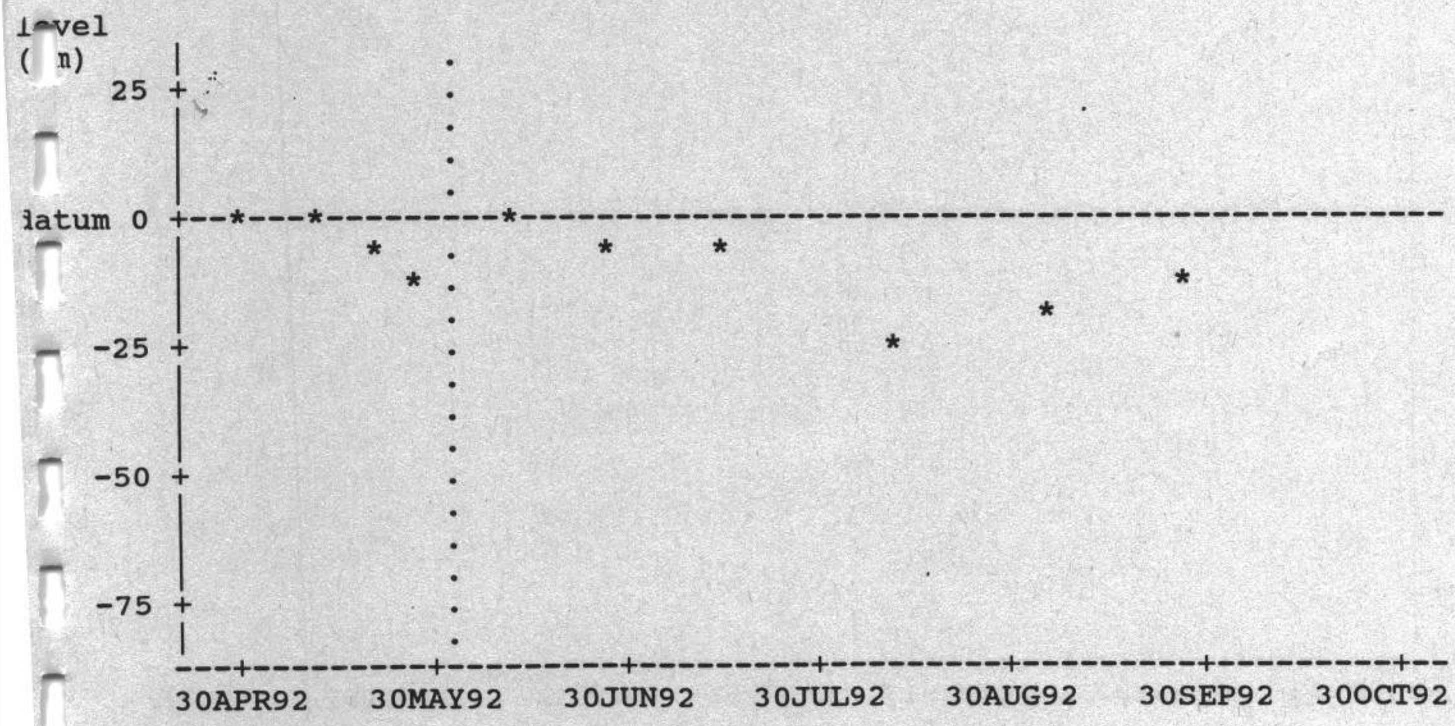
CHANGES IN WATER LEVEL IN POOL 9, MIDDLE FEN, DURING 1992



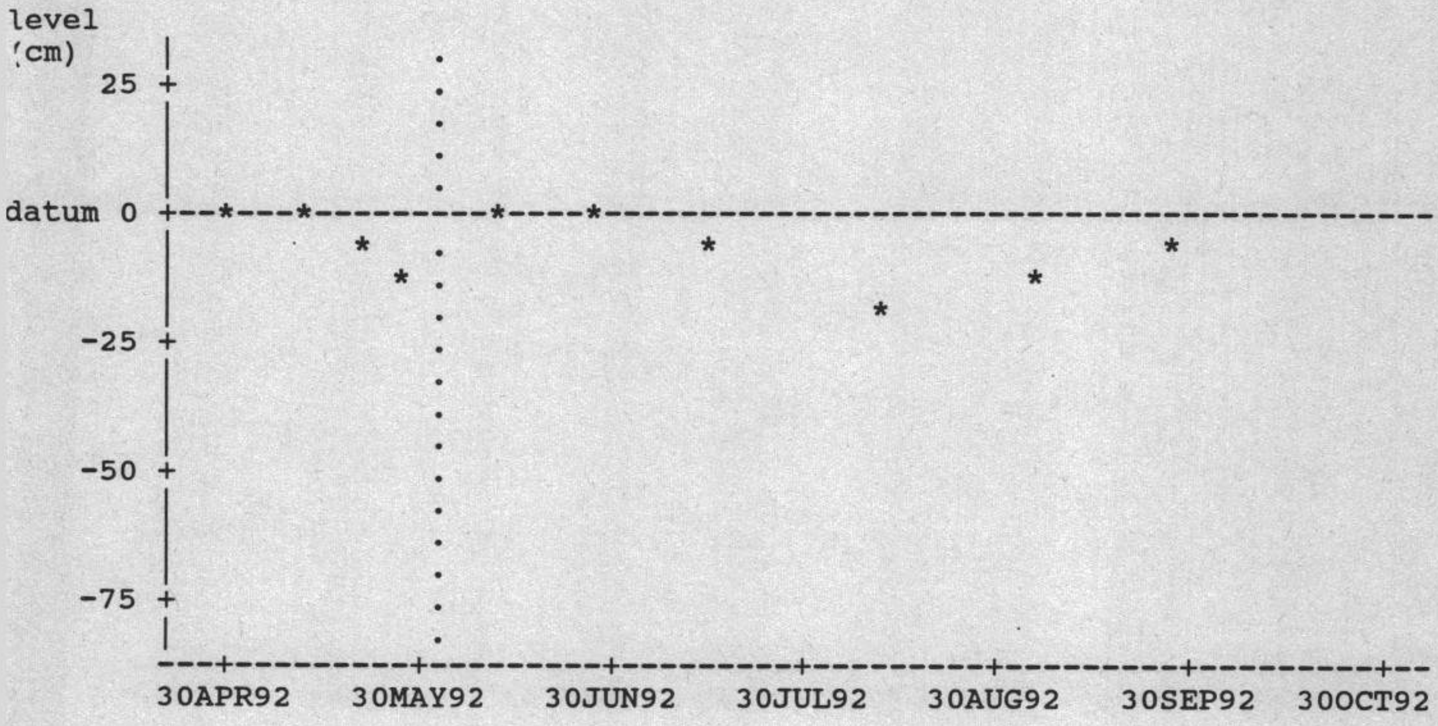
CHANGES IN WATER LEVEL IN POOL 10, MIDDLE FEN, DURING 1992



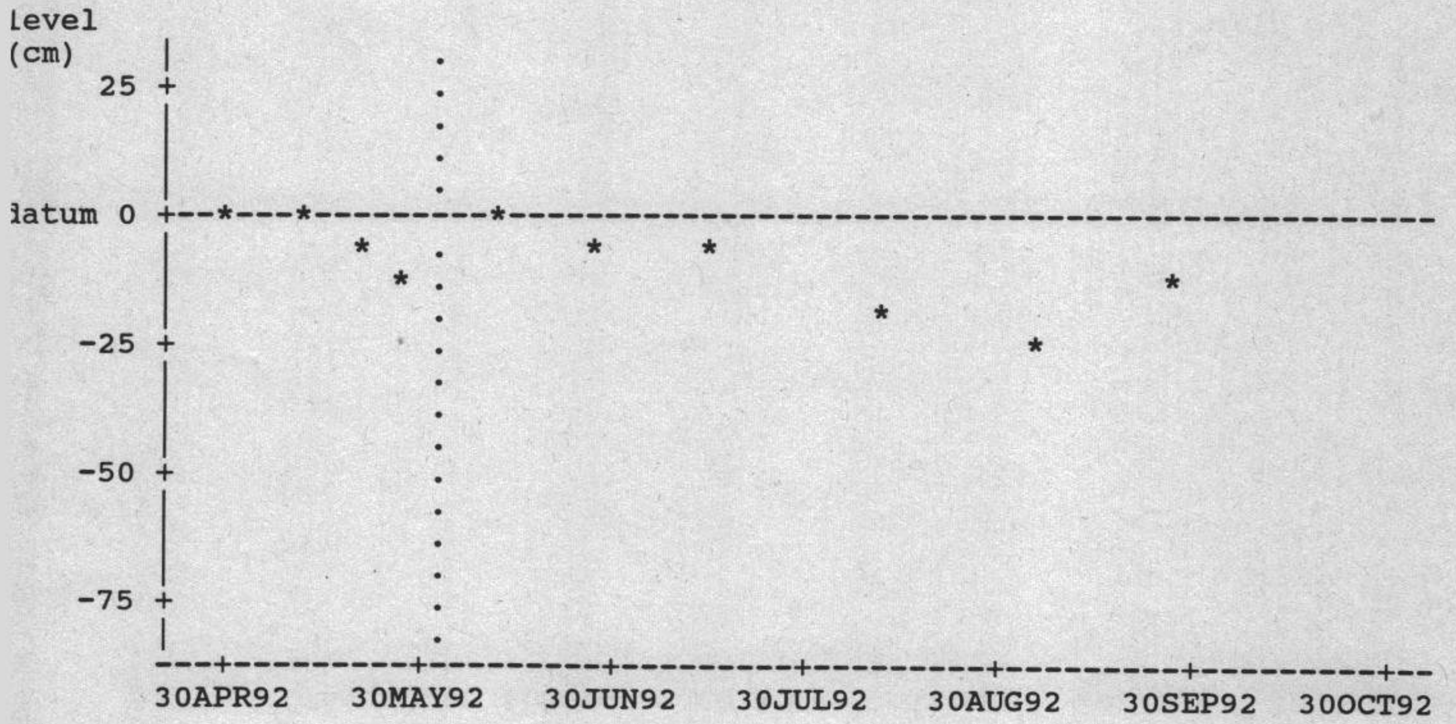
CHANGES IN WATER LEVEL IN POOL 11, MIDDLE FEN, DURING 1992



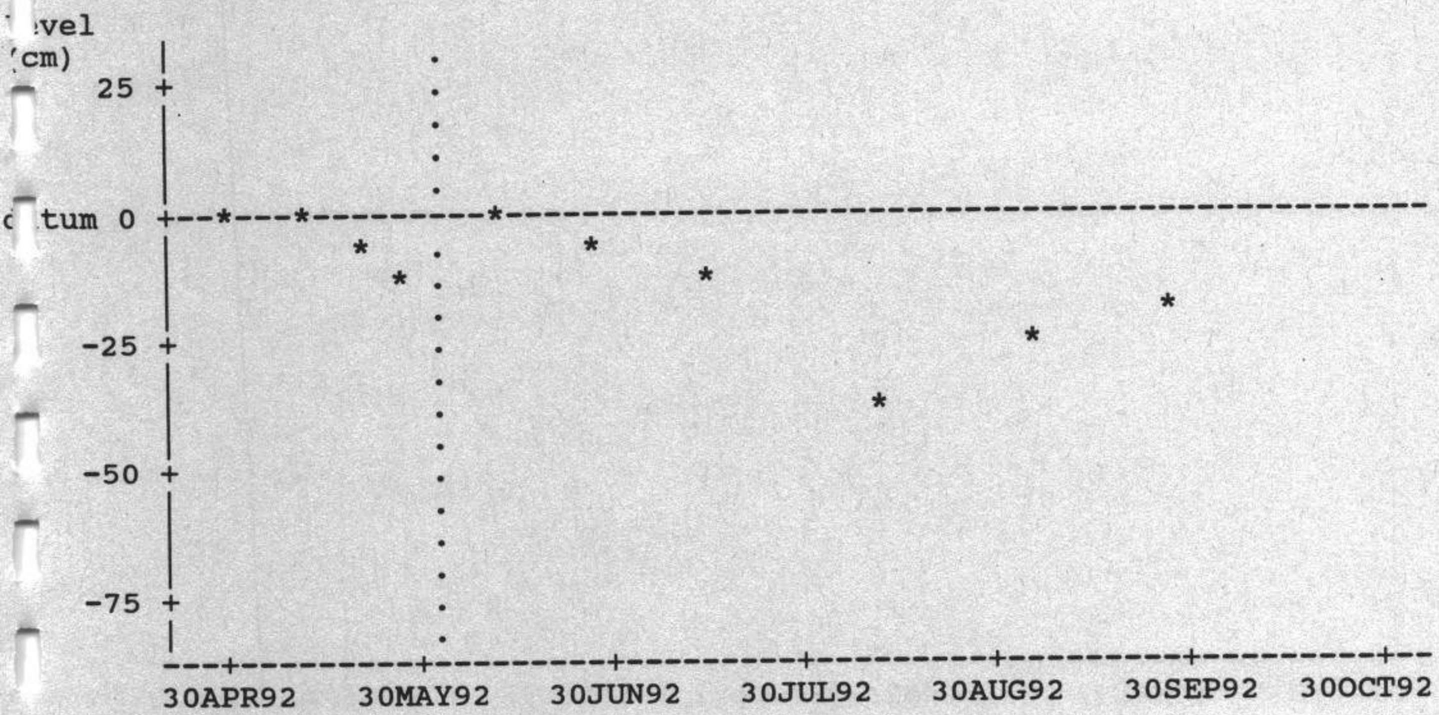
CHANGES IN WATER LEVEL IN POOL 12, MIDDLE FEN, DURING 1992



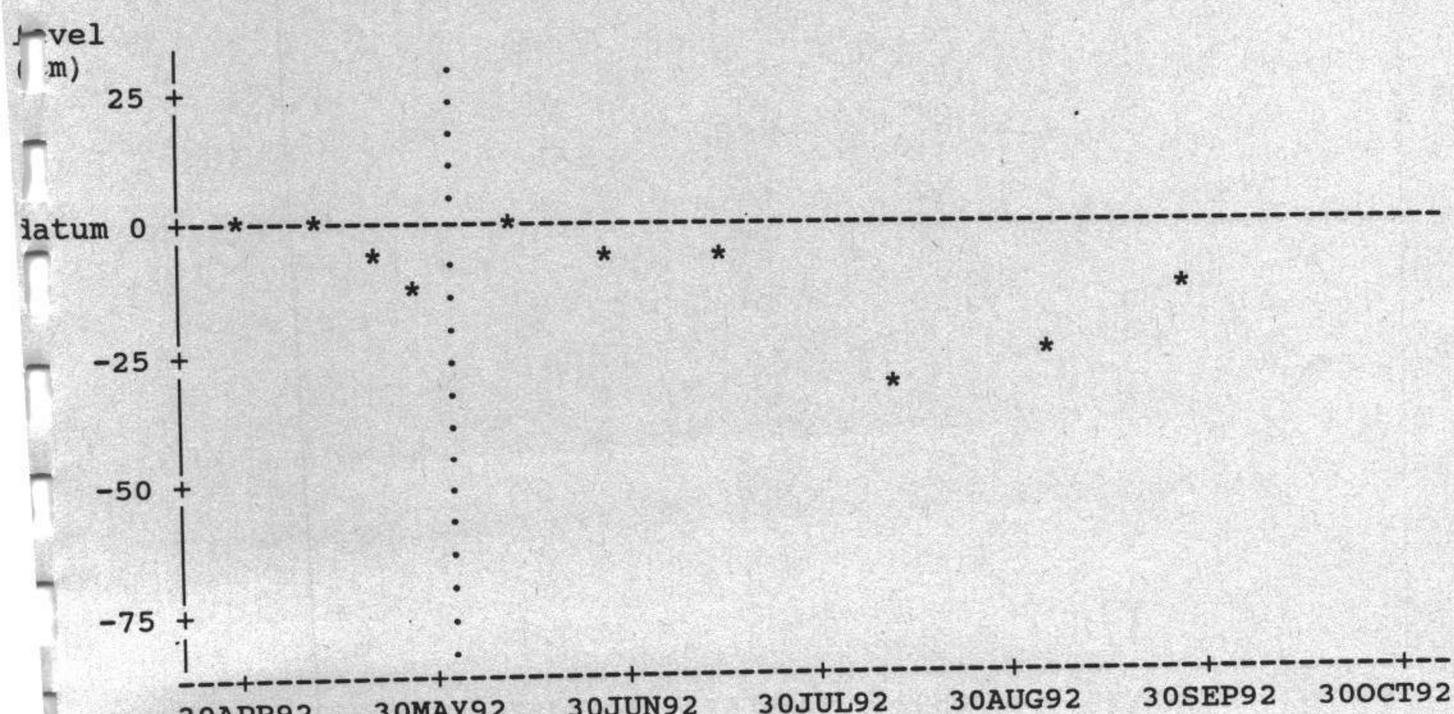
CHANGES IN WATER LEVEL IN POOL 13, MIDDLE FEN, DURING 1992



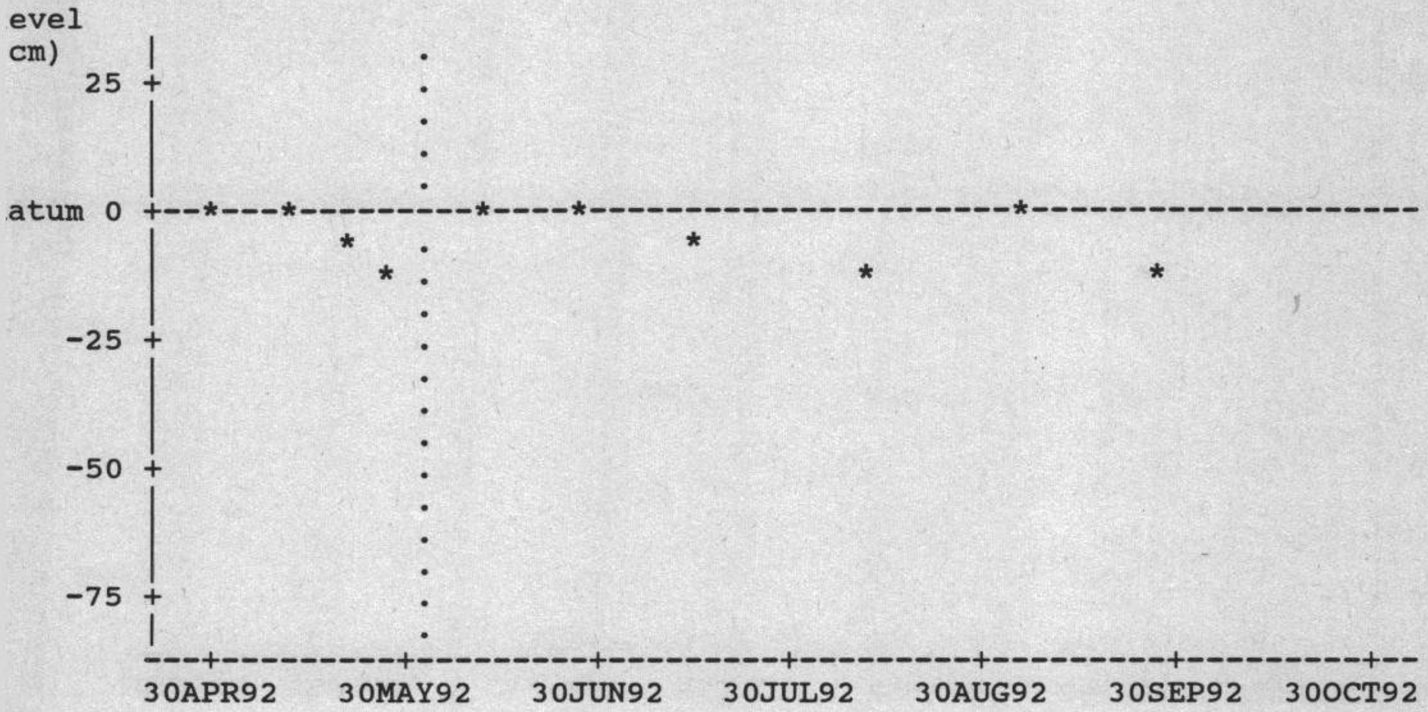
CHANGES IN WATER LEVEL IN POOL 14, MIDDLE FEN, DURING 1992



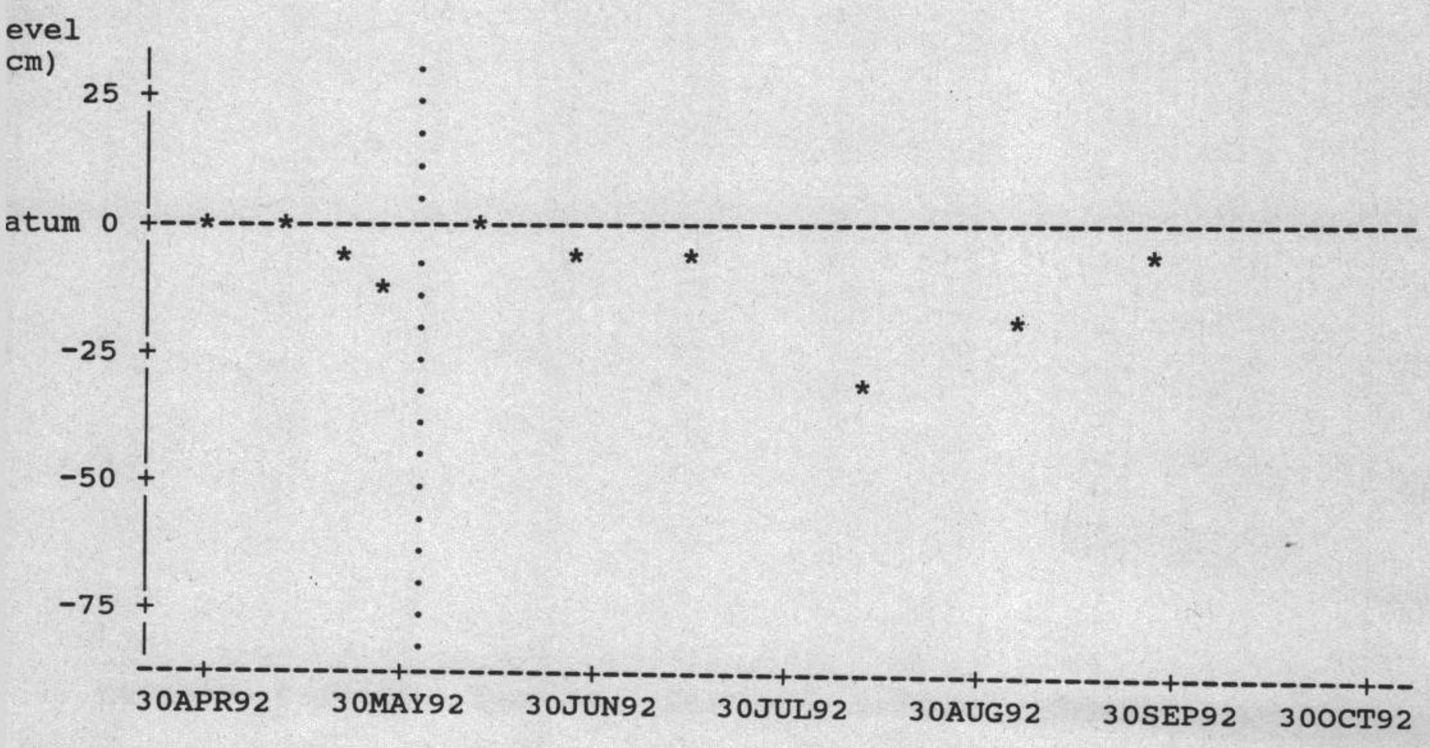
CHANGES IN WATER LEVEL IN POOL 15, MIDDLE FEN, DURING 1992



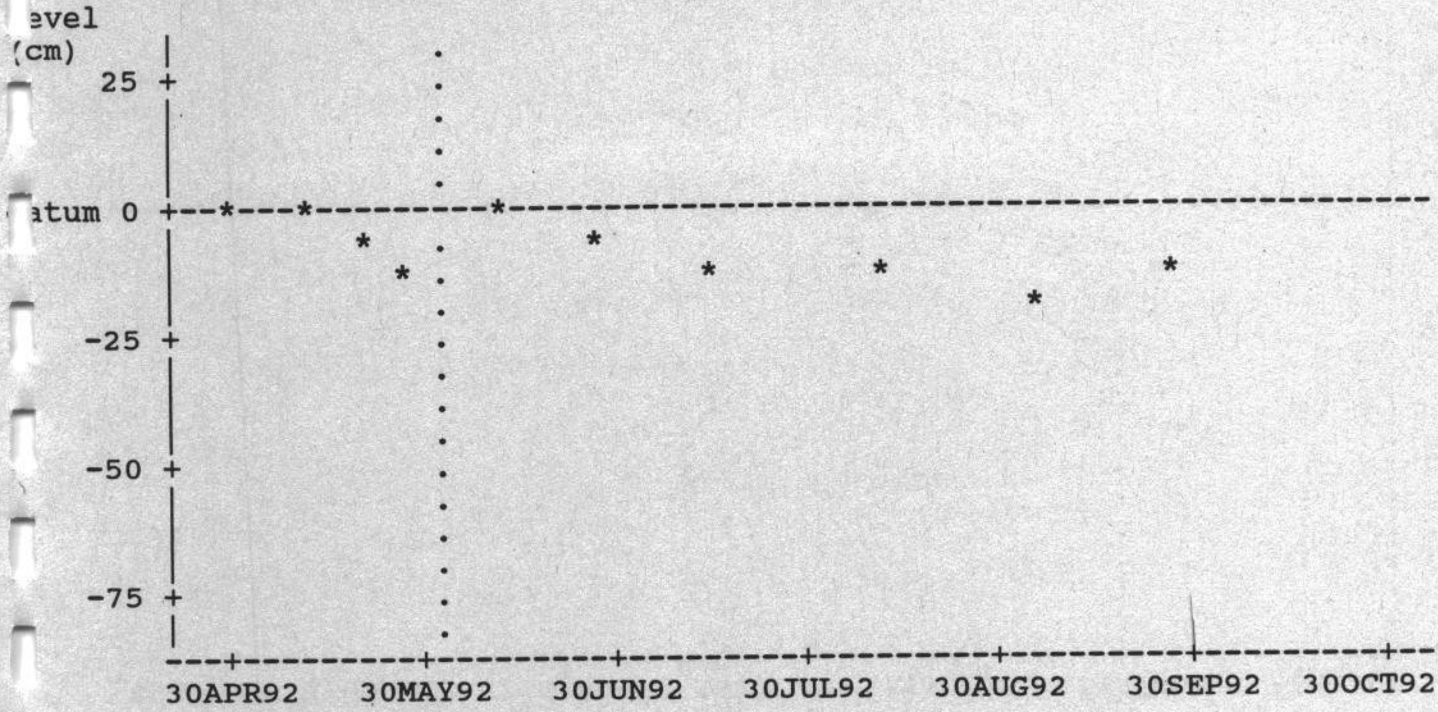
CHANGES IN WATER LEVEL IN POOL 16, MIDDLE FEN, DURING 1992



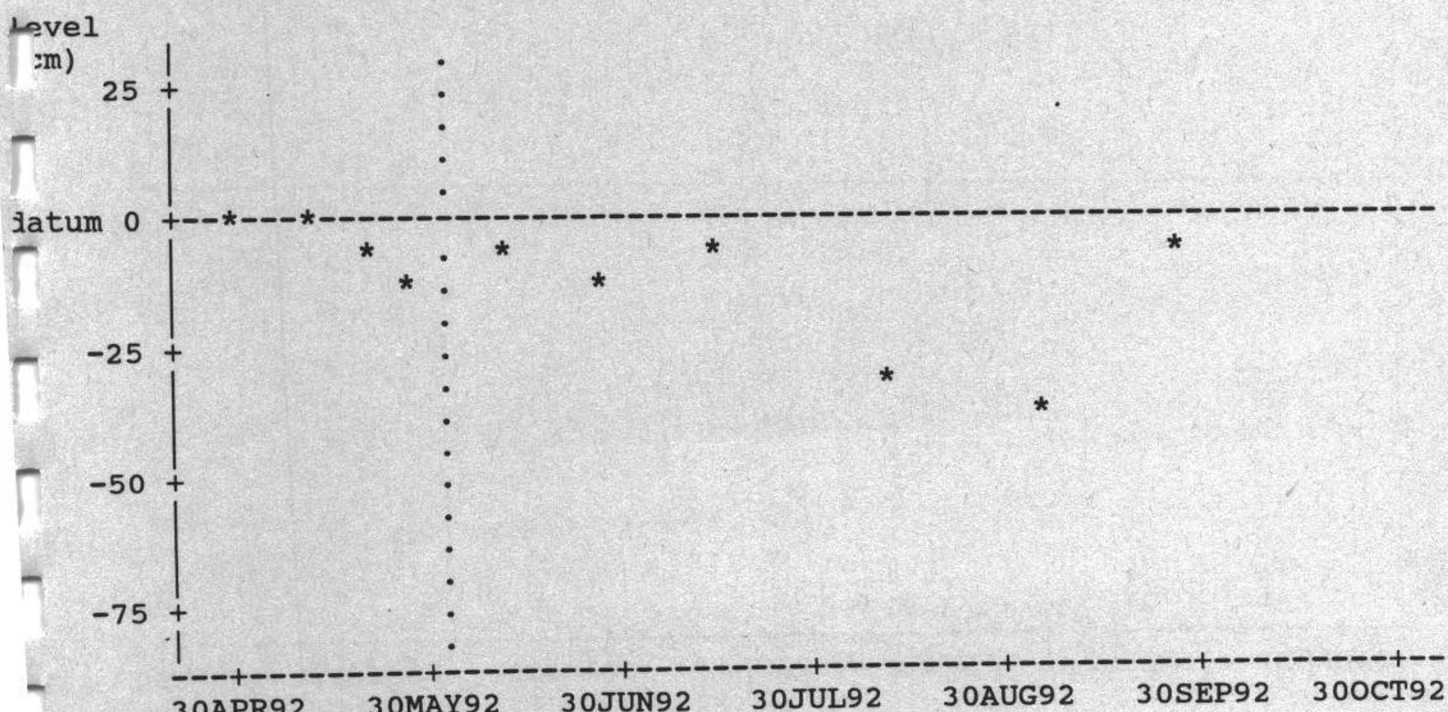
CHANGES IN WATER LEVEL IN POOL 17, MIDDLE FEN, DURING 1992



CHANGES IN WATER LEVEL IN POOL 18, MIDDLE FEN, DURING 1992



CHANGES IN WATER LEVEL IN POOL 19, MIDDLE FEN, DURING 1992



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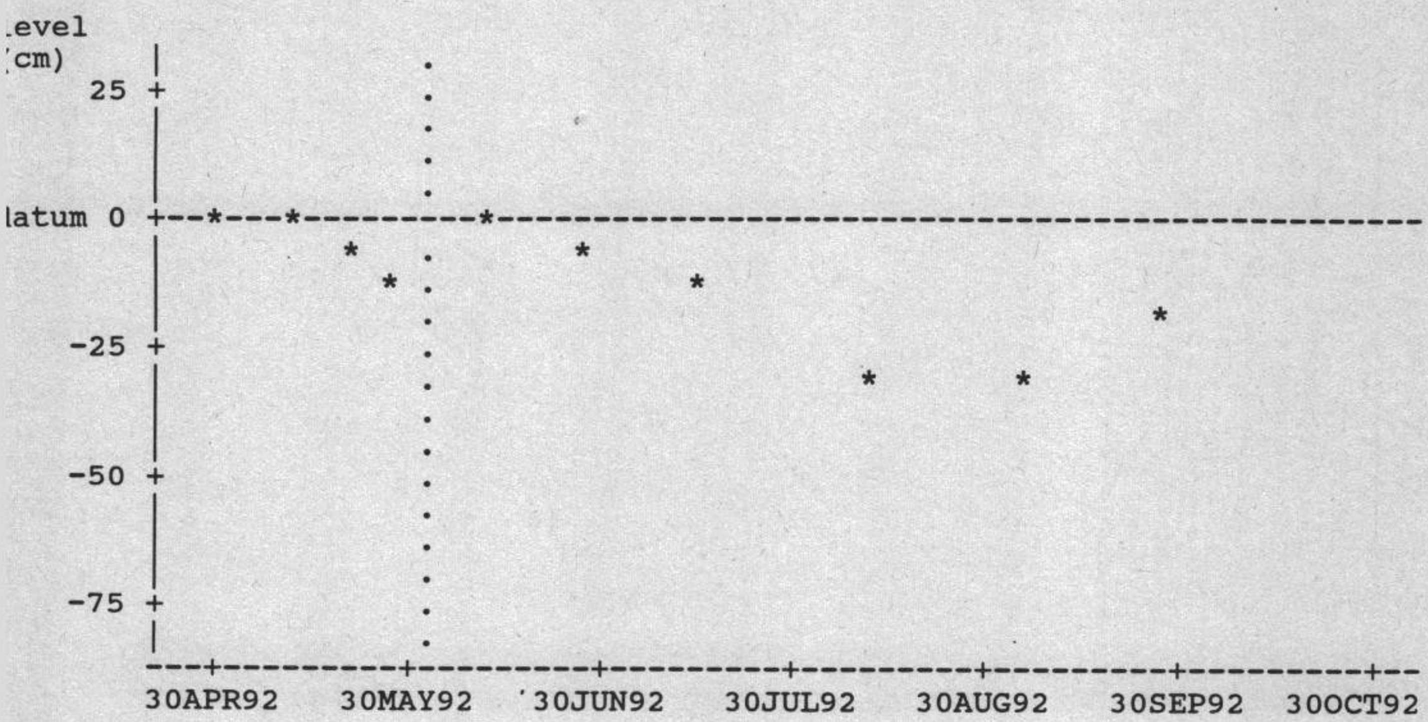

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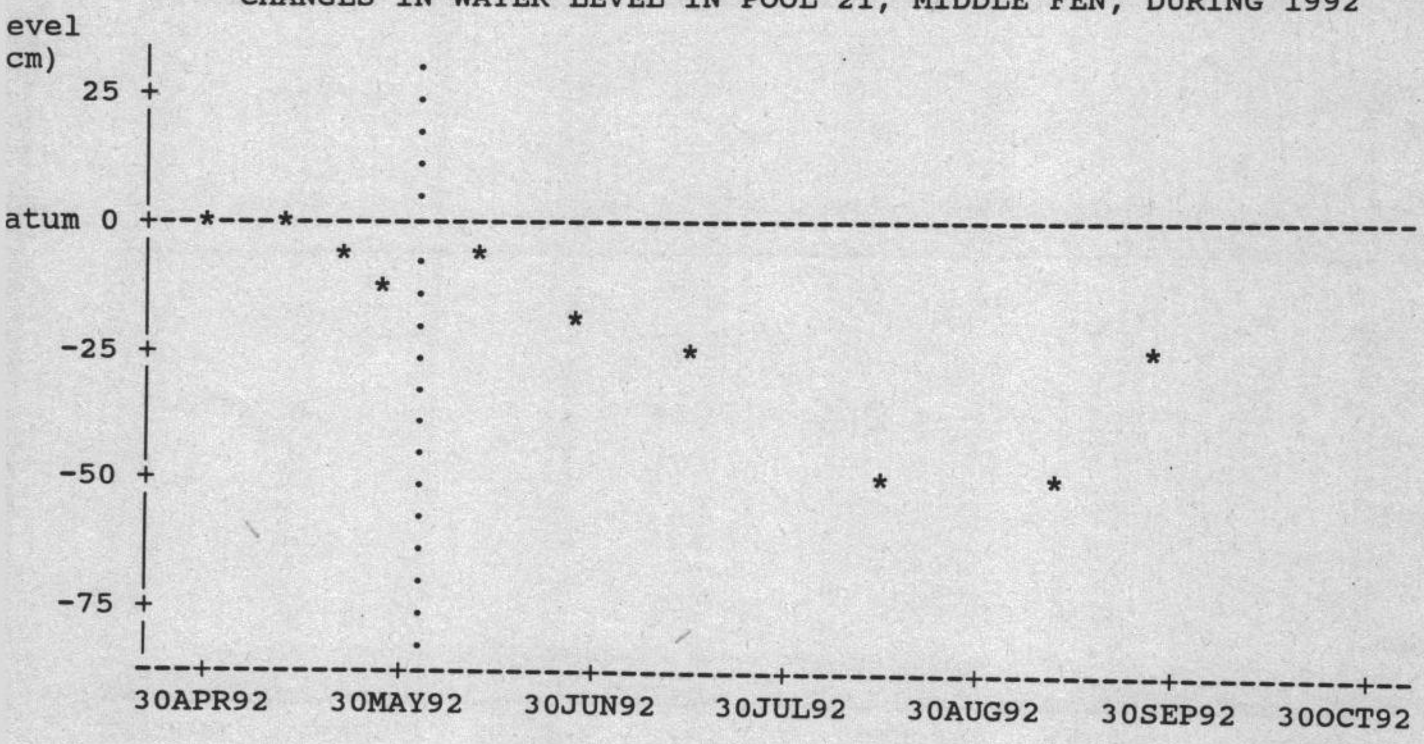

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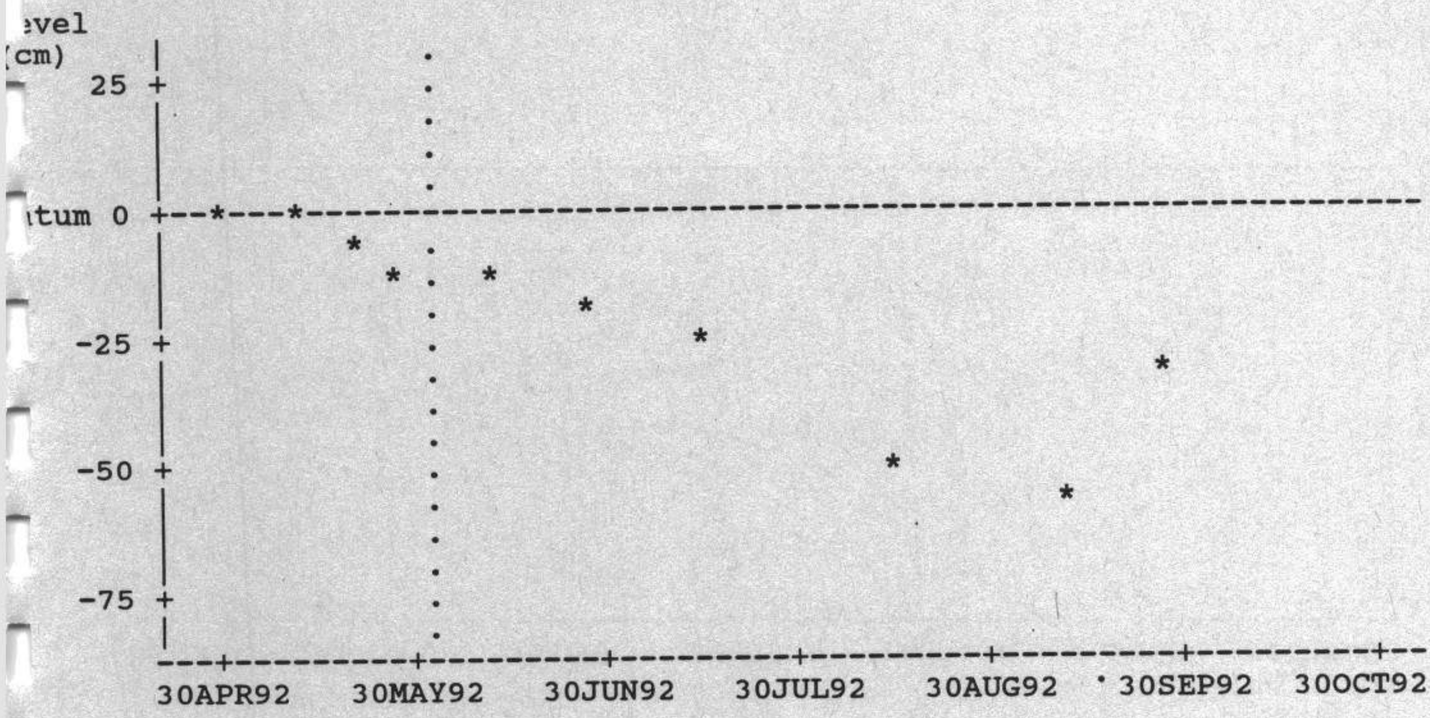

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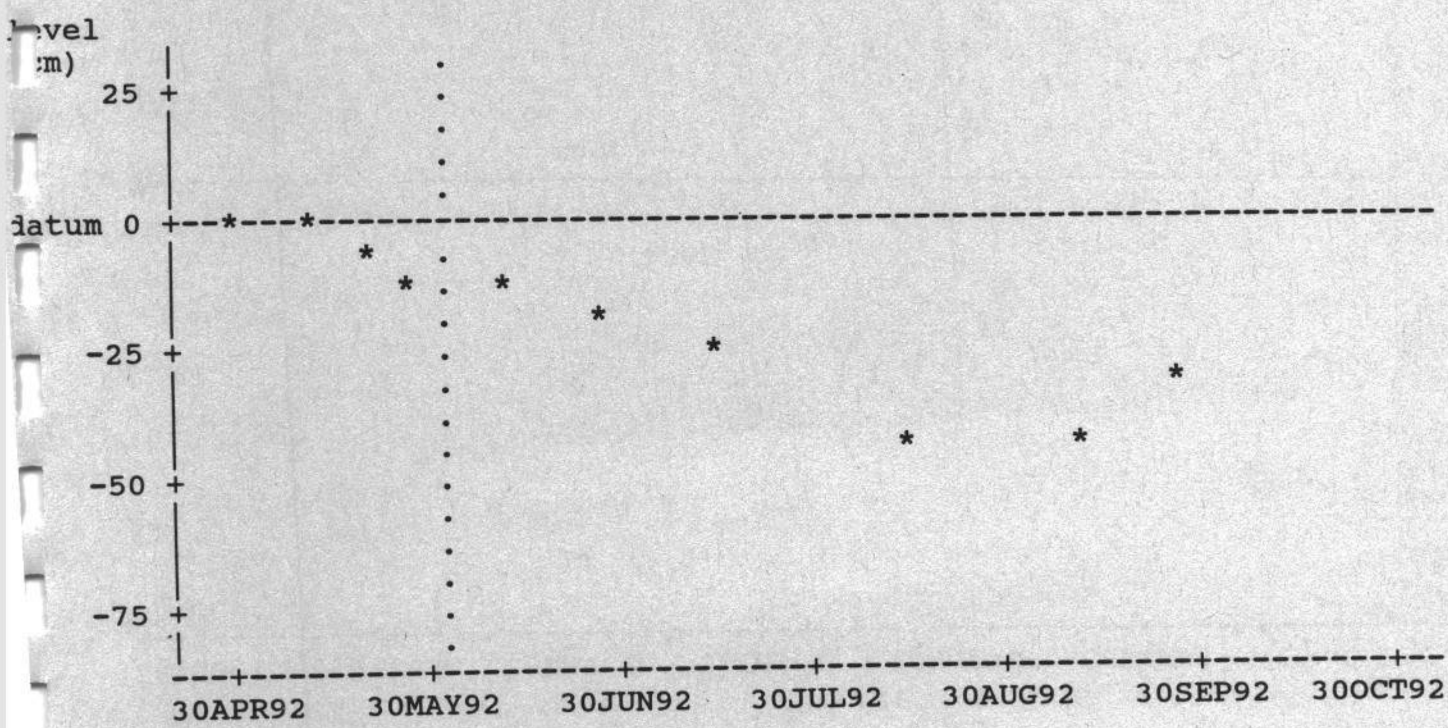
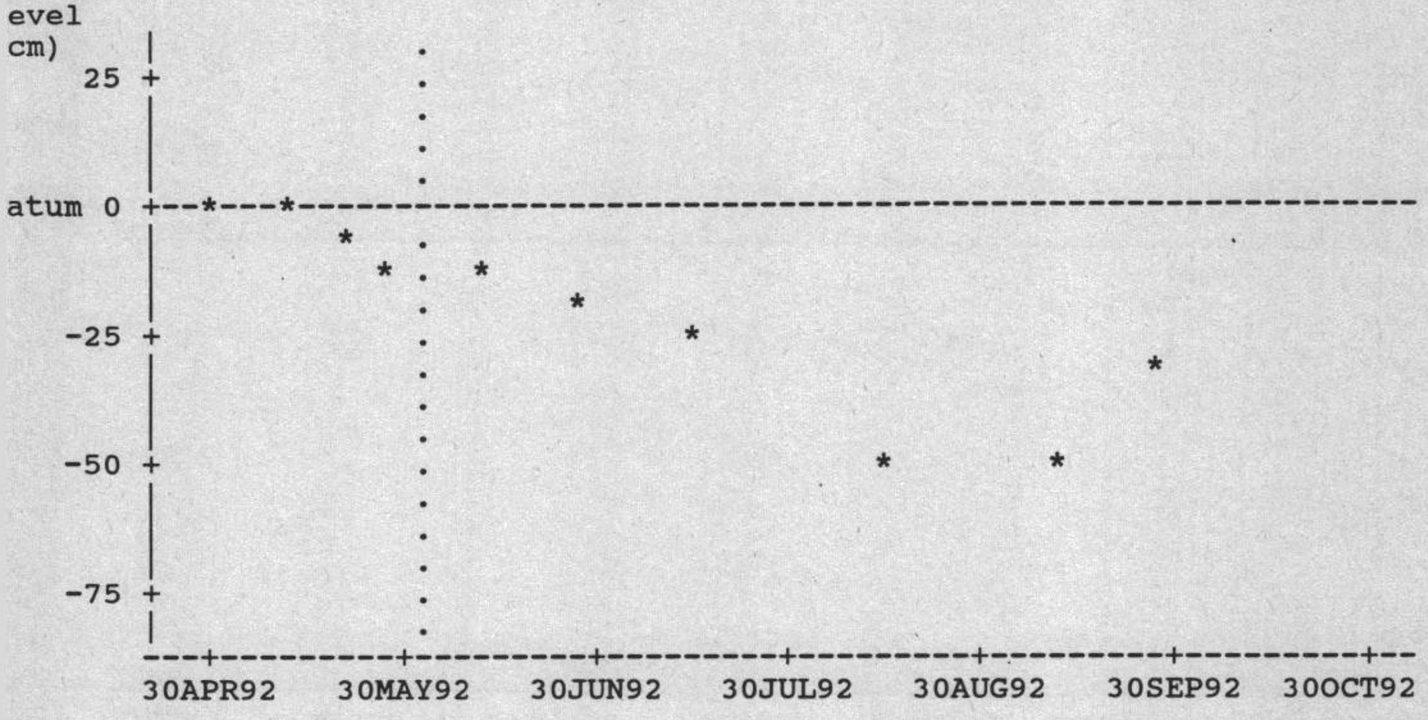


CHANGES IN WATER LEVEL IN POOL 24, MIDDLE FEN, DURING 1992



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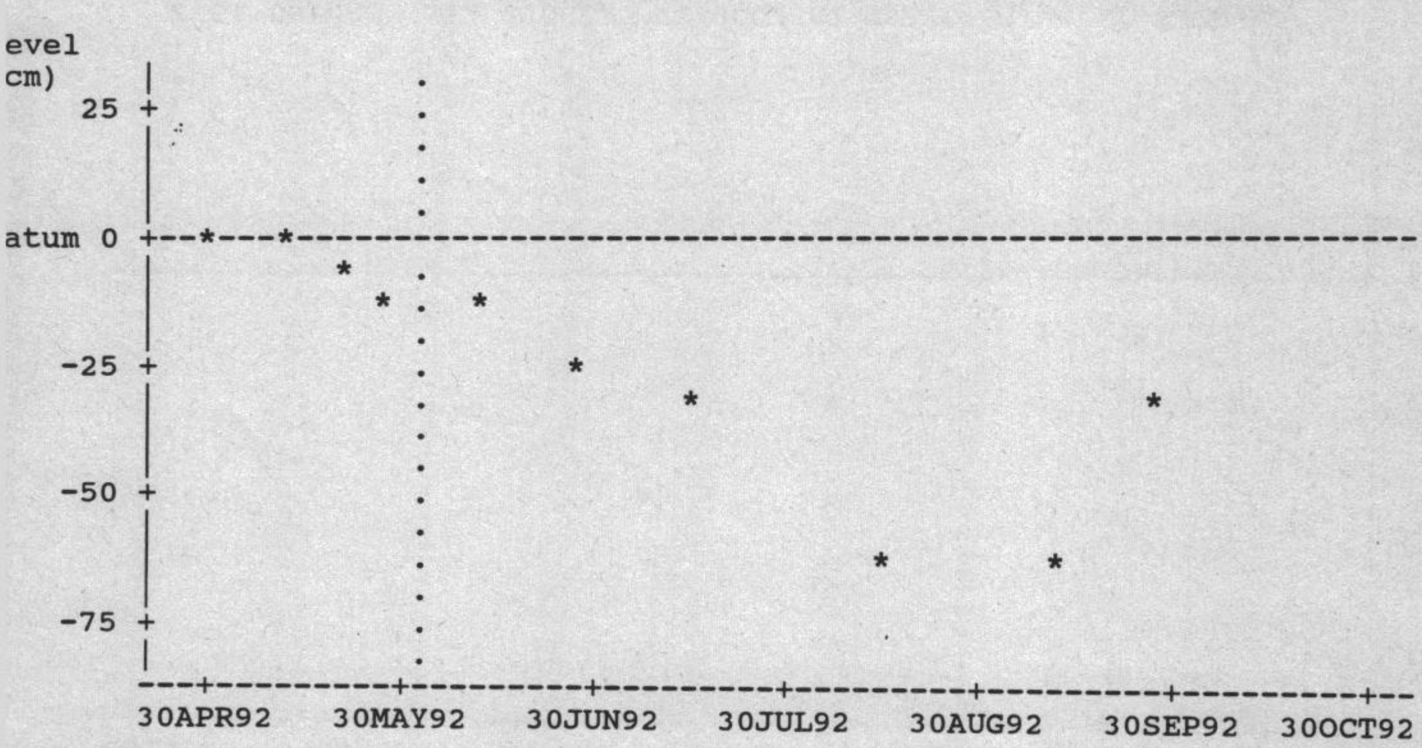
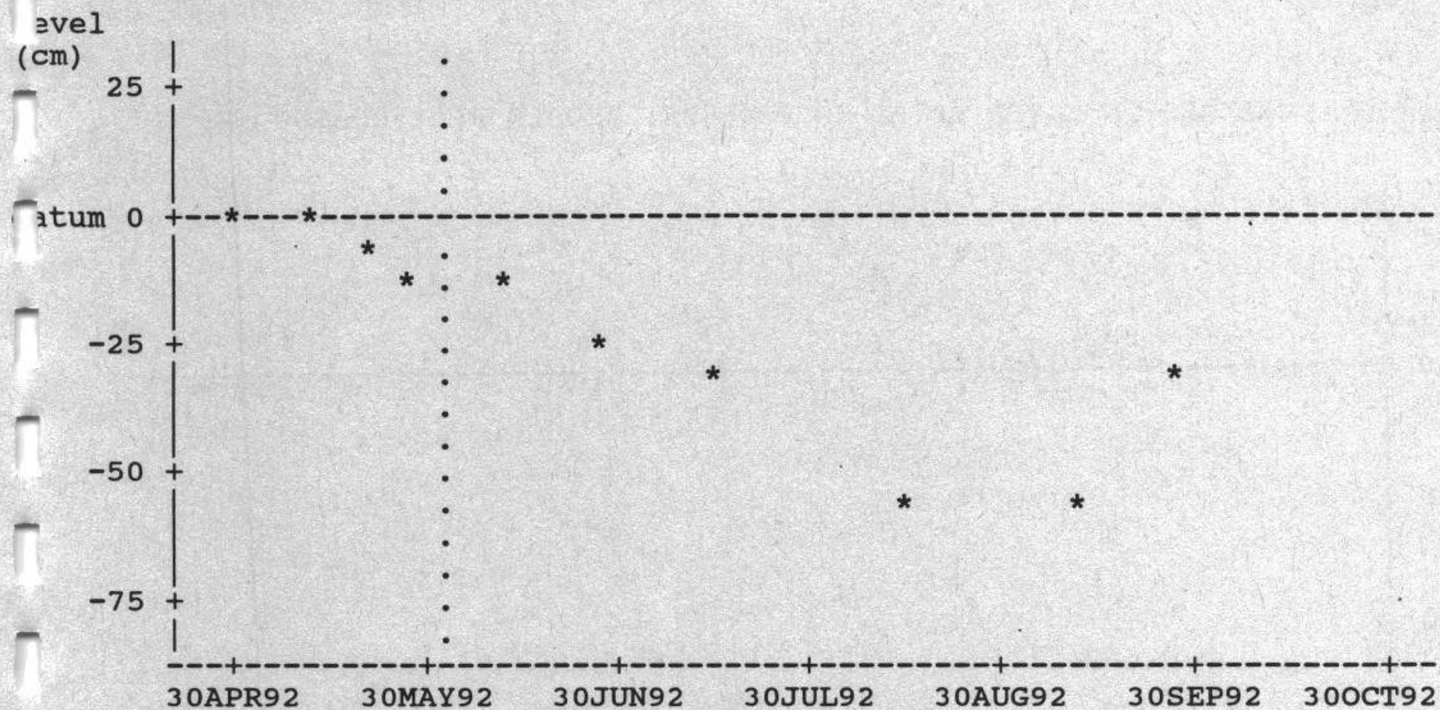
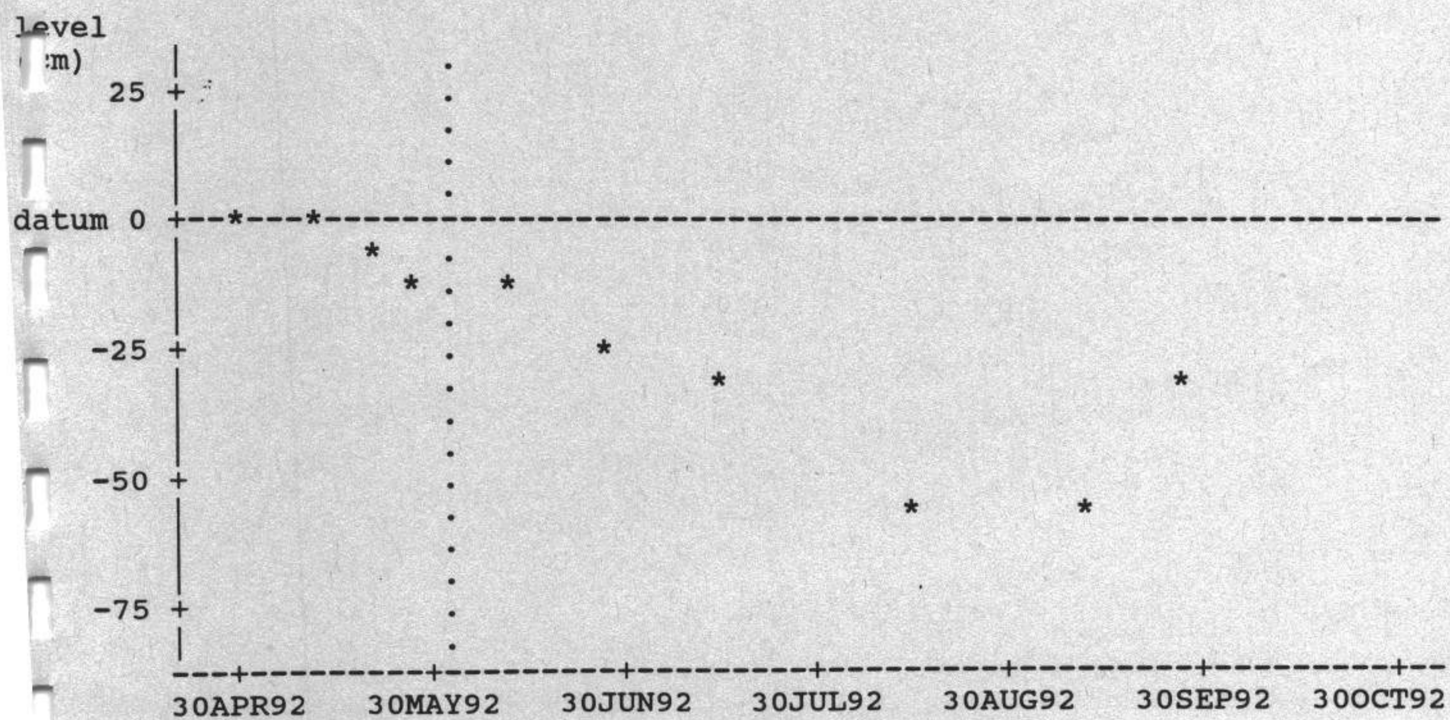


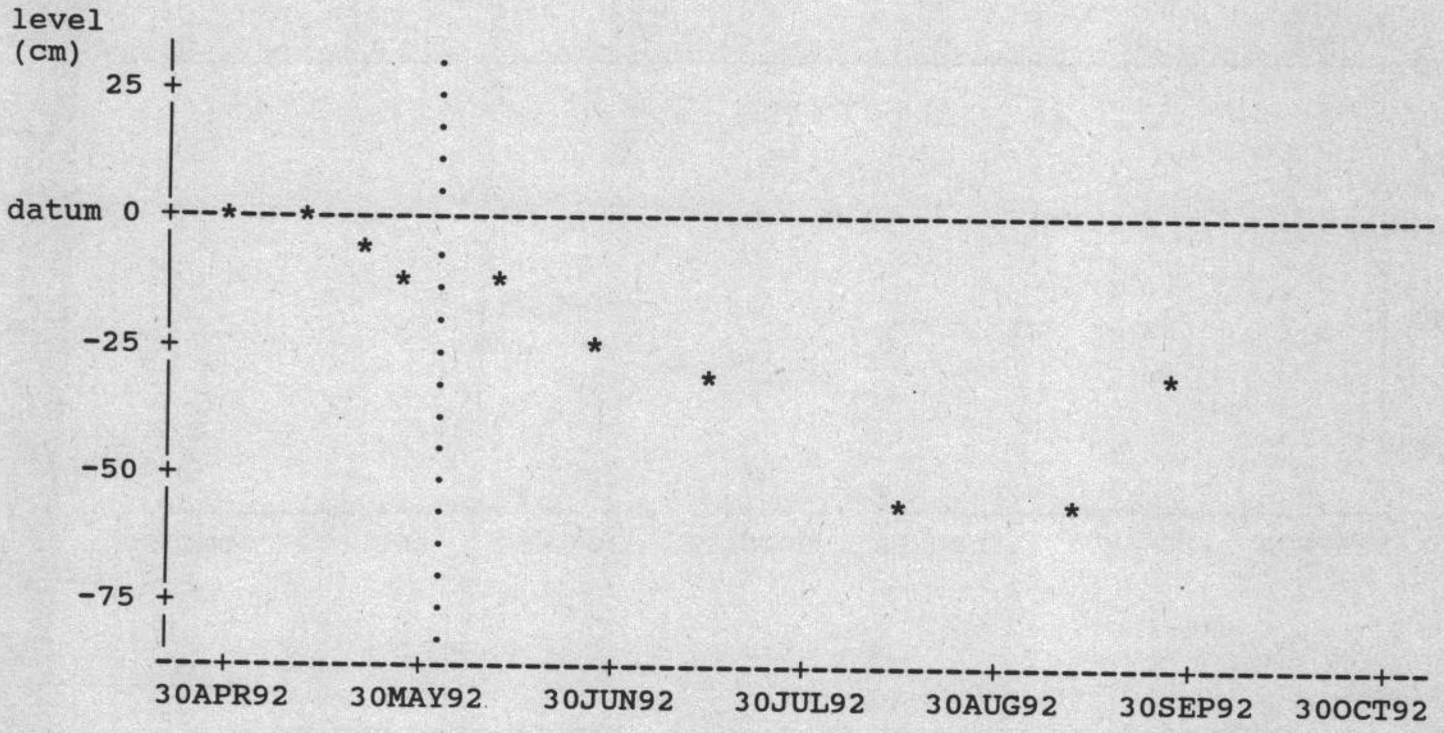
CHANGES IN WATER LEVEL IN POOL 26, MIDDLE FEN, DURING 1992



CHANGES IN WATER LEVEL IN POOL 27, MIDDLE FEN, DURING 1992



CHANGES IN WATER LEVEL IN POOL 28, MIDDLE FEN, DURING 1992



Appendix 3 FEEDING OBSERVATIONS

D. plantarius were observed feeding on six occasions. Sufficient of all prey items was visible for approximate identification. The sex and size/age class of spider and the prey items are listed below:

D. plantarius	Prey item
Adult male	*Pirata* sp.
14 mm female	*Pirata* sp.
12 mm female	*Pirata* sp.
Adult female	Water beetle sp. (*ca* 5mm)
Adult female	Frog hopper sp.
10 mm juvenile	Gnat sp.

There were no observations of *D. plantarius* being predated although predation of young in the webs was suspected (Section 3.3.2).

Appendix 4 RATIOS OF BANDED AND UNBANDED MORPHS

D. plantarius commonly occurs with both banded and unbanded morphs in the same population. Duffey (1991) recorded a much lower frequency of the unbanded morph of on Middle Fen than on Little Fen. This was also true in 1992. Using the same method of estimation as Duffey, the frequencies were 12.5 % on Little Fen and 2.4 % on Middle Fen. These compare with 11.8 % and 4 % respectively in 1991. Kennett (1985) found that 13 % of spiders on Little Fen were unbanded and quotes a figure of 6 % recorded in the same area by D. Orr in 1977.

There was also considerable variation between individuals in the colour and width of the bands, in celpalothorax and abdomen colour, and in the occurrence of spotting on the abdomen. Occasionally these patterns were sufficiently distinct to aid in re-identification of individuals. In general, however, it would not be feasible to use colour and pattern variation as a reliable system for individual identification in the field. It also seemed likely that band colour changed with age and stage. For example, all banded pregnant and post-partum females were recorded as having cream bands, although white as well as cream bands were common amongst immatures.