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The Effect of the Cardiff Bay Barrage on Waterfowl Populations 7. Distribution and Movement Studies August 1995-May 1996

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EXECUTIVE SUMMARY

1. This report represents the results of the seventh season of intensive monitoring of the wildfowl and waders using the intertidal areas in Cardiff Bay and its environs. More extensive monitoring at low tide also covered the intertidal areas between Cardiff Bay and the mouth of the River Usk. The results presented in this report were derived from data collected between August 1995 and May 1996. The monitoring programme followed that used for the previous six years, allowing direct comparisons to be made between the seven years of study.

2. By early 1998, the intertidal mudflats of the Taff and Ely estuaries (known as Cardiff Bay) will be inundated by fresh water when the bay is flooded prior to the completion of the amenity barrage. The gathering of information on the distribution and movement of the populations of waders and wildfowl both before and after barrage completion will help make it possible to assess their fate when the barrage has been built.

3. Monitoring the populations of waders and wildfowl on the northwest Severn from Cardiff Bay to the Usk Estuary has revealed only minor changes in the number and distribution of birds compared with 1994/95.

4. The detailed data collected for Taff/Ely, Orchard Ledges and Rhymney were used to obtain estimates of the size and distribution of wader and wildfowl populations at each site. There was evidence of changes in feeding distribution of three of the four main species, Dunlin, Curlew and Redshank. In winter, Dunlins avoided mudflats 3, 4 and 5, the latter perhaps due to disturbance from the building of the barrage. Both Curlews and Redshanks, likewise, avoided mudflats adjacent to the barrage in autumn. In winter, however, both species renewed their use of these mudflats in spite of continuing work.

5. Continuing colour-ringing studies have indicated that a high proportion of the Redshank population of Cardiff Bay may be faithful to it through the winter. A small proportion of birds, however, were observed at both Cardiff Bay and Rhymney. A knowledge of their site-fidelity will be important in determining their behaviour after the bay inundated.

6. Thirty-eight individually colour-ringed Redshanks observed in March 1996 will provide a sample from which an over-summer return rate to the bay will be calculated, thus indicating the species' site-fidelity between winters. Future observations will help determine winter and annual survival rates.

7. Catches of Redshanks at Cardiff Bay and at Rhymney allowed analysis of the species mass changes through winter. Birds were heaviest in December, prior to the worst winter weather.

GENERAL INTRODUCTION

Work on the amenity barrage across the mouth of Cardiff Bay started in 1994 and is still continuing at present. The major areas where work took place between August 1995 and May 1996 were as follows (see Figure 2.1.1):

- On the eastern side of the bay, where deposition of rubble and stone extended the barrage westwards into the bay through autumn and winter. This involved many lorry journeys to tip the huge boulders onto the site and the use of large diggers to position the material. As well as directly affecting the mudflat on which this was occurring, this work involved considerable movement of vehicles near to mudflats and much noise.

- On the western (Penarth) side of the bay, where deposition of rubble and stone extended the barrage eastwards into the bay through autumn and winter. A bascule bridge was built in winter and spring to connect the two sides of the barrage and to allow lorries to cross.

- On mudflats on the eastern side of the bay, where a channel to link the yacht club at the northeastern part of the inner harbour with the River Taff in the centre of the bay was dredged in midwinter.

These developments have changed the size of some of the mudflat feeding areas in the bay from the previous year. Additionally, they have caused considerable disturbance at the mouth of the bay, where birds pass on their way to and from the estuary and other feeding areas.

The intensive monitoring of waders and wildfowl during the study period from 1989/90 to 1995/96 has given a good picture of their numbers and distribution in the area. It is important to continue this level of monitoring as the changes within the bay may affect the behaviour of the birds wintering in the area. The effect of the barrage closure on the local bird populations will only be accurately determined if their status is known immediately prior to closure.

Theoretical aspects of the behaviour of waders and wildfowl overwintering on estuaries have been covered in previous reports and need not be repeated here.

Some changes had previously affected the feeding and roosting behaviour of birds in the bay. The building of the Peripheral Distributor Road (PDR) resulted in the loss of some mudflat areas, the filling in of an old canal and much disturbance in the northwest part of the bay. The effects that this had on the waders and wildfowl that used this part of the study site have been covered in previous reports (Toomer & Clark, 1992a, 1992b, 1993, 1994; Toomer *et al.*, 1993, 1994, 1995). The building of the barrage is likely to have similar effects from this winter until completion.

This report covers the distribution and movement of the birds in Cardiff Bay and nearby areas and is in two sections. The first part summarizes the results of the seventh year of monitoring waterfowl populations in the Cardiff Bay area. The second looks at the results of studies of the site-fidelity and survival of Redshanks.

The results of the first six years' monitoring of the waders and wildfowl populations found during the autumn, winter and spring in Cardiff Bay and nearby areas were given by Evans *et al.* (1990), Donald & Clark (1991a), Toomer & Clark (1992a) and Toomer *et al.* (1993, 1994, 1995). This report summarizes the sixth autumn and the seventh winter and spring of wader and wildfowl monitoring.

Data from the Wetland Bird Survey (WeBS) for the mean peak winter counts of waterfowl for the Taff and Ely estuaries (Cardiff Bay) and the Severn Estuary as a whole, together with the percentages of the British and European populations for winter 1995/96 were not available at the time of writing this report. The importance of the Severn Estuary will be referred to in the species accounts using data for the 1994/95 winter (Waters *et al.*, 1996).

PART 1: DISTRIBUTION STUDIES

1. INTRODUCTION

This first part of the report discusses the results of studies on the feeding distributions of waterfowl using the Taff/Ely (i.e. Cardiff Bay), Orchard Ledges and Rhymney study areas between August 1995 and May 1996. The findings have been compared with the results of the previous six years (Evans *et al.*, 1990; Donald & Clark, 1991a; Toomer & Clark, 1992a; Toomer *et al.*, 1993 and 1994). The distribution of roosting birds on the Taff/Ely site was studied in the 1990/91, 1991/92, 1992/93 and 1993/94 winters (Donald & Clark, 1991b; Toomer & Clark, 1992b; 1993 and 1994).

With seven years of data it is possible to assess year to year variation in bird numbers and their feeding distribution. Changes that have occurred to the bird populations, or to their behaviour, during this time are examined in the species accounts and discussed later.

The timing of the autumn fieldwork has varied for the first three studies (see Toomer *et al.*, 1993). For this, the sixth autumn of the study, observations were made for the three months of the defined autumn period: August, September and October, allowing direct comparisons to be made with the two previous autumn studies.

The winter and spring fieldwork has been carried out for the same periods (November-March and April-May respectively) and the results are therefore directly comparable.

In this report special attention is given to the development at the mouth of Cardiff Bay. The building of the barrage and associated dredging have resulted in the loss of small areas of mudflat. Feeding birds would have been affected both by the loss of habitat and the disturbance associated with this work.

2. METHODS

The methods used in this seventh year of study were similar to those in the six previous studies and therefore are described only briefly below. Using the same methodology allows direct comparisons to be made between seasons and years for the seven year period.

Two types of counts were carried out, all day counts and low tide counts.

2.1 All Day Counts

The study area consisted of three sites: Taff/Ely (Figure 2.1.1), Orchard Ledges and Rhymney (Figure 2.1.2). Each site was divided into several mudflat count areas to allow detailed analyses of results. The Taff/Ely site was divided into 19 count areas, Orchard Ledges into two count areas and the Rhymney into 17 count areas. The boundaries of the count areas were those laid down in the first year of monitoring (Evans *et al.*, 1990).

Developments continued at the mouth of the Taff/Ely estuary during the current study. The building of the barrage cut across mudflat 18 at the east of the bay and across mudflats 2 and 5 at the western side (reducing their area by 50, 60 and 12% respectively). In addition, mudflat 17 was cut by dredging (reducing its area by 29%) to produce a channel linking the yacht club and the River Taff (see Figure 2.1.1). Birds using these four mudflats were thus subject to disturbance for much of the winter. The four observation points that had been used in the previous years of study were used again. Extra observations were made from the jetty area of the yacht club and from the leisure centre opposite sector 8 if feeding flocks were seen to be using nearby areas.

No changes in the Orchard Ledges and Rhymney sites were observed over the previous six seasons of monitoring and counts were made from the same observation points.

The pitted area between Orchard Ledges and the Rhymney sites holds small populations of Oystercatchers *Haematopus ostralegus*, Dunlins *Calidris alpina*, Curlews *Numenius arquata* and Turnstones *Arenaria interpres* at low tide. The nature of the broken surface made it very difficult to count birds accurately from either the Orchard Ledges or Rhymney observation points. As with the previous studies, this area was not counted.

Counts were divided into three seasons: autumn (August-October 1995), winter (November 1995-March 1996) and spring (April-May 1996). With the exception of early spring, April, each site was counted at least twice a month with one count on a spring tide and one on a neap tide where possible. All count areas of each site were counted once every hour from six hours before to five hours after low tide. Counts were made throughout the hours of daylight or for 12 hours (whichever was the shorter). This procedure enabled the assessment of changes in the usage of different sites throughout the tidal cycle. Feeding and roosting birds were counted separately and factors such as disturbance to the site or impaired visibility were noted. All birds present on the exposed mudflats were counted. Wildfowl feeding in the shallow water offshore, which were clearly feeding on invertebrates or plants on or in the substrate were included in the counts. However, wildfowl roosting offshore on the open water were not included in the counts as the study is primarily concerned with feeding birds and because such birds are extremely difficult to count. Also, birds roosting on open water may not be making any use of the area and roosts on water are not confined to the three sites. Waders and wildfowl roosting in areas of saltmarsh were not counted, as accurate counts are also very difficult in this habitat. Observations on the roosting behaviour of birds in Cardiff Bay have been covered in separate reports (Donald & Clark, 1991b; Toomer & Clark, 1992b; Toomer & Clark, 1993; Toomer & Clark, 1994).

Following Evans *et al.* (1990) and Toomer *et al.* (1993), for each season, all day counts were used to calculate the following:

1. the average exposure time per tidal cycle of each mudflat;
2. the average number of feeding bird hours per tidal cycle ('all day usage' - the term 'usage' will be used throughout the report) for each species for each mudflat;
3. the average number of feeding bird hours per tidal cycle per hectare (mean feeding usage density) for each species for each mudflat;
4. the average number of birds of each species present on each of the three sites at each hour of the tidal cycle and the proportion feeding.

All day usage was calculated as:

$$\sum_{A=+5}^{A=-6} (B \times C)$$

where A is the hours from low tide (0 hours being low tide and +5/-6 high tide, B is the average number of birds feeding at time A when the area was exposed and C is the proportion of counts when the area was exposed at time A.

2.2 Low Tide Counts

The low tide distribution of waterfowl in the northwest Severn was monitored using counts made of all the areas during the period two hours either side of low tide. Counts were made at two-weekly intervals during the winter period. As for the previous studies, only areas along the north Severn shore, west of the River Usk were counted as it was considered that changes in Cardiff Bay were most likely to affect the distribution of birds in this area (Figure 2.2.1). As with the all day counts, the whole area was broken down into smaller count areas. These were larger on average than the all day count areas. The average number of feeding birds present on each of the count areas is shown for each species.

2.3 Presentation of Results

The previous six years of study were reported in Evans *et al.* (1990), Donald & Clark (1991a), Toomer & Clark (1992a), Toomer & Clark (1993), Toomer *et al.* (1994) and Toomer *et al.* (1995). Some figures from the latter two reports are reproduced here for comparison with this year's results. As other previous results are not reproduced, however, the present report should be read in conjunction with the previous six.

All species observed at the three sites during the period of study are discussed, but most emphasis is given to Shelduck *Tadorna tadorna*, Dunlin, Curlew and Redshank *Tringa totanus* for which the areas are most important. For these four main species, accounts are divided into three sections: autumn 1995, winter 1995/96 and spring 1996. For other species discussion concentrates on the winter period. In each section maps of the 'all day usage' of the mudflat count areas are presented. Comparison maps are given for the two previous years (1993/94 and 1994/95). In addition, for Shelduck, Dunlin, Curlew and Redshank, maps of mean feeding usage density are presented in the winter accounts. The results are considered in relation to the changes that have occurred to the sites during the seven years of study, as well as the feeding ecology, behaviour and migration patterns of the waterfowl.

Presentation of the results of the all day counts follows Evans *et al.* (1990). Graphs showing the number of birds and the proportions feeding through the tidal cycle only give the percentage feeding if a total of 50 birds or more were present during any one tidal hour.

The order of the species accounts follows Voous (1973).

3. RESULTS AND SPECIES ACCOUNTS

3.1 Shelduck

Shelducks breed in Britain and Ireland at many coastal locations, but increasingly, at inland sites (Gibbons *et al.*, 1993). Following breeding, most adult Shelducks move to moulting grounds on the German Wadden Sea and start to return to their winter areas from September onwards. There is a small but important moulting population at Bridgwater Bay on the south side of the Severn. The British wintering population has remained steady in recent winters with the wintering population estimated at 65,000 in 1994/95 (Waters *et al.*, 1996). The Severn Estuary is of international importance for Selduck in winter.

Autumn 1995

During the autumn few Shelducks were present on any of the three study sites. Only a very few were present at Taff/Ely, feeding on the central mudflats along the River Taff (Figure 3.1.1). No Shelducks were observed at Orchard Ledges during the autumn. Numbers were also low at Rhymney, although almost all mudflats were used (Figure 3.1.2). Feeding numbers at Rhymney were higher, however, than in the previous two autumns.

Shelducks used the Rhymney mudflats throughout the low water period, with a peak mean number of over 80 birds (Figure 3.1.3c). The feeding pattern of the birds was somewhat erratic, with large numbers ceasing to feed for short periods after low tide.

Winter 1995/96

Low tide counts showed feeding Shelducks to be present along the whole of the northwest Severn during the winter of 1995/96 (Figure 3.1.4). No Shelducks were recorded at Orchard Ledges during low tide counts. The main concentration of feeding birds on the other sections of the northwest Severn was found at Peterstone, but all sectors that extended to the lower shore supported populations of feeding Shelducks.

At Taff/Ely, feeding Shelducks were widely distributed over the mudflats, with fewest birds being found on the northwest part of the study site (Figure 3.1.5). The numbers of feeding birds and their distribution in the bay were similar to the two previous winters. Shelducks continued to use mudflats close to the mouth of the bay, in spite of the building work there. Densities of Shelducks in each of the three winters were highest in the centre of the bay, along the River Taff and along the eastern channel to the yacht club (Figure 3.1.6).

Groups of up to 20 Shelducks were observed feeding on sector 1 at Orchard Ledges (Figure 3.1.7). The main area used by feeding birds was the muddy bank at the extreme western end of sector 1, which was only exposed for a short period around low tide. At Rhymney, all sectors were used by feeding Shelducks at some time during the tidal cycle (Figure 3.1.7). Feeding Shelducks were usually concentrated near the water's edge, especially to the east of the mouth of the River Rhymney where the highest levels of usage were observed. The pattern of usage was similar to that seen in the two previous winters. Densities of Shelducks in each of the three winters were highest on mudflats 12 and 13 in the lower intertidal zone, but were comparitively low on mudflat 14, due to its large area (Figure 3.1.8).

There were two peaks in Shelduck numbers at Taff/Ely during the tidal cycle (Figure 3.1.9a). Shelducks that had been roosting in the saltmarsh or on the open water, moved onto the mudflats to feed as the tide receded. With a further fall in water level, some birds moved back onto the open water, while others left the study site to feed elsewhere. The low numbers of Shelducks

at Orchard Ledges were present during the four hour period around low tide, when suitable feeding substrate was exposed (Figure 3.1.9b). At Rhymney, most Shelducks flew from roost areas to the east to feed on the recently uncovered mudflats. The number of birds rose sharply after high tide, with the peak mean being about 800, a slightly higher figure than in the previous winter (Figure 3.1.9c). The majority of the birds continued to feed while the lower mudflats were exposed.

The usage of the three sites in winter has risen, albeit erratically, over the seven years of study ($r_s = 0.679$, $n = 7$, ns; Figure 3.1.10). This has been due primarily to an increased usage of the Rhymney mudflats. The mean feeding usage density of Shelducks at Cardiff Bay was slightly lower than that at Rhymney (8.1 bird hours per tidal cycle per hectare, compared with 10.1).

Spring 1996

Relatively high numbers of Shelducks usually remain into spring. At Taff/Ely, some feeding birds were found on all mudflats, but the highest levels of usage were in the middle of the bay (Figure 3.1.11). Two Shelducks were observed several times feeding on muddy areas at Orchard Ledges. Almost no feeding Shelducks were seen on areas to the west of the Cardiff Eastern Sewer at Rhymney, most being present on mudflats 13-16 (Figure 3.1.12). The numbers and distribution of Shelducks at each site were similar to those seen in spring 1995. Numbers, particularly at Rhymney, were lower than those recorded in spring 1994, however.

The spring population of Shelducks at Taff/Ely was about half that found in the winter, with most of the birds staying at the study site over the low tide period (Figure 3.1.13a). At Rhymney, the spring population had declined to about a tenth of the wintering population (Figure 3.1.13c).

3.2 Dunlin

Almost 10,000 pairs of Dunlins breed in Britain, mainly in the flows of northern Scotland and on peaty bogs in the English and Scottish uplands (Stroud *et al.*, 1987). The wintering population is boosted by the arrival of large numbers of migrant birds from the north. There was a minimum wintering population of over 530,000 birds around the estuaries and shores of Britain in 1994/95 (Waters *et al.*, 1996). The Severn Estuary holds internationally important numbers of Dunlins during the winter.

Autumn 1995

Dunlins present in early autumn are likely to be birds on passage to their wintering grounds in Africa. Only relatively small numbers of these birds have been found to stop over at the study sites. Few Dunlins were seen during autumn at Taff/Ely, with a maximum number of 23 being present for a short time in October. Feeding birds were present on several sectors (Figure 3.2.1). No Dunlins were present on Orchard Ledges during the autumn. At Rhymney, up to 90 birds were seen during the autumn. These were mainly observed feeding on mudflats to the east of the River Rhymney (Figure 3.2.2). The distribution of Dunlins in each of the study sites was similar to that recorded in the previous two autumns, although numbers at Rhymney were lower.

The peak mean number of Dunlins at Taff/Ely was less than 15 birds (Figure 3.2.3a). At Rhymney most Dunlins were present on the falling tide, feeding on the newly exposed mud surfaces, producing a peak of activity before low tide (Figure 3.2.3c).

Winter 1995/96

Large numbers of feeding Dunlins were seen along the northwest Severn during low tide counts (Figure 3.2.4). Almost all sections had feeding birds present, with the highest concentrations on St. Brides and parts of Peterstone. Higher numbers of feeding Dunlins were present on the eastern mudflats of Peterstone than in the previous winter.

At Taff/Ely, most feeding flocks were observed on mudflats adjacent to the River Taff in the centre of the bay, with sectors 4, 6 and 17 having the highest levels of usage (Figure 3.2.5). Almost all sectors were used by some feeding birds. The numbers and distribution of feeding Dunlins in the bay were similar to the previous winter. In the winter of 1993/94, however, many more Dunlins used the bay, particularly mudflats 3, 4 and 5 to the west of the River Taff. Densities of Dunlins in each winter were also highest on central mudflats adjacent to the River Taff, notably mudflat 6 (Figure 3.2.6).

A maximum of 370 Dunlins were seen at Orchard Ledges, many fewer than in the previous winter (Figure 3.2.7). Birds fed on both mudflats, but were usually there for one to two hours only. At Rhymney, the highest numbers of feeding Dunlins were recorded to the east of the Cardiff Eastern Sewer (Figure 3.2.7). Dunlins arrived at the site on the falling tide, most moving along the shore from the east. The shore to the west of the Cardiff Eastern Sewer was usually occupied last, when most of the intertidal zone had become exposed. Mudflats 7, 8 and 9, therefore, were used in preference to mudflats 1-6 higher up. Many fewer Dunlins used mudflats 1-9 than in the two previous winters. Otherwise the distribution and numbers of Dunlins at Rhymney remained the same. Densities of Dunlins in each of the three winters were highest along the River Rhymney and on mudflats along the lower intertidal (Figure 3.2.8). Although mudflat 14 held high numbers, densities were low due to its large area.

At Taff/Ely, there were peaks in Dunlin numbers shortly before and shortly after high tide (Figure 3.2.9a). Many of these birds roosted in the saltmarsh whilst mudflats were covered. Nearly all Dunlins left the bay over the low water period to feed elsewhere. The peak mean number of less than 500 Dunlins was only half that of the 1994/95 winter and only a quarter of that of the 1993/94 winter. Dunlins were present at Orchard Ledges during the entire exposure period, although numbers peaked at low tide (Figure 3.2.9.b). At Rhymney the peak mean number of 3500 birds also occurred at low tide (Figure 3.2.9c). This figure was only 70% of that for the previous winter.

Although the usage of the three sites has declined over the past three winters, there has been no general trend in usage over the seven year study period ($r_s = 0.179$, $n = 7$, ns; Figure 3.2.10). The mean feeding usage density of Dunlins at Cardiff Bay was one third that at Rhymney (17.5 bird hours per tidal cycle per hectare, compared with 45.6).

Spring 1996

The number of Dunlins decreased after the February counts, and very few were present at the three study sites after the end of March. Dunlins seen during spring were likely to be on passage north from wintering areas in Africa. At Taff/Ely small groups of less than five birds were seen feeding on mudflats 14 and 17 in April (Figure 3.2.11). Only four Dunlins were seen at Orchard Ledges in spring. At Rhymney, groups of up to 50 birds were present during April (Figure 3.2.12). Here, the small number of birds occurred in two peaks, before and after low tide (Figure 3.2.13c). Very few Dunlins have been seen during previous springs.

3.3 Curlew

The Curlew characteristically breeds on damp upland moorlands, but this century has colonised many lowland regions, especially agricultural habitats (Gibbons *et al.*, 1993). The breeding population of Britain and Ireland has been estimated at 45-50,000 pairs (Reed, 1985). Some of this population winters in France, but many other Curlews from continental Europe, especially Scandinavia, migrate to Britain to winter (Prater, 1981). A minimum population of 88,000 wintered on the estuaries and shores of Britain in 1994/95 (Waters *et al.*, 1996), an increase on the previous year (Cranswick *et al.*, 1995). The Severn Estuary holds internationally important numbers of Curlew during winter.

Autumn 1995

Curlews usually return early to their wintering grounds and by the beginning of autumn they were present at all three study sites. At Taff/Ely, Curlews moved from their roost sites in the saltmarsh onto neighbouring mudflats as the tide receded. Most birds did not feed immediately, but continued to roost. When the tide was low enough to uncover adjacent feeding sites, many birds left the bay. The distribution of feeding Curlews in the bay differed from the two previous autumns, in that fewer used mudflat 2 close to the mouth of the bay (Figure 3.3.1). This mudflat had been reduced in size by the building of the barrage and was disturbed by continuing work. In contrast, mudflats 6, 17 and 18 supported higher numbers of Curlews than in the previous autumn. Many of the Curlews that left Taff/Ely on the falling tide moved onto Orchard Ledges to feed, where both mudflats had high levels of usage (Figure 3.3.2). At Rhymney, Curlews used mudflats close to Orchard Ledges and those to the east of the River Rhymney, notably mudflats 14 and 15 (Figure 3.3.2).

The pattern in the numbers of Curlews recorded at Taff/Ely was consistent with the observations described above. There were two clear peaks, three hours either side of low tide (Figure 3.3.3a). These peaks were mainly of non-feeding birds. With the approach of low tide many Curlews left the bay. Most of those remaining fed during the low tide period. At Orchard Ledges, Curlews fed for the entire exposure period, approximately three hours before to three hours after low tide. There was a peak mean of over 60 birds, a slightly lower figure than in the previous autumn (Figure 3.3.3b). The pattern of Curlew numbers through the tidal cycle at Rhymney, like that at Taff/Ely, showed two peaks (Figure 3.3.3c). Curlew roosted away from the site, but moved onto eastern mudflats as the tide ebbed. Some birds left the site to feed elsewhere at low water, but returned on the flood tide. The peak mean number of Curlews at Rhymney was similar to those in the two previous autumns.

Winter 1995/96

Low tide counts of feeding Curlews showed that they were very widespread along the northwest Severn (Figure 3.3.4). The highest concentrations were found at Taff/Ely, the western mudflat of Rhymney (i.e. Orchard Ledges), the eastern mudflats of Peterstone and on the eastern mudflats of St Brides. Numbers were lower than in the previous winter on nearly all mudflats.

Previous observations have not shown major changes between autumn and winter populations of Curlews at the study sites. Birds return to the study area by early autumn and appear to remain faithful to feeding sites through winter. At Taff/Ely feeding birds were present on many sectors, but the highest levels of usage were found on mudflats near the mouth of the bay and in its centre, adjacent to the River Taff (Figure 3.3.5). The distribution of feeding Curlews was similar to that seen in the two previous winters, although numbers were less than those in 1993/94. Mudflat 2, which had been avoided in autumn and in winter 1994/95, probably due to barrage work, had the highest level of usage. Densities of feeding Curlew in each of the three

winters were highest on central mudflats, adjacent to the River Taff, and along the channel to the east of the bay (Figure 3.3.6).

Fewer Curlews used the mudflats at Orchard Ledges and Rhymney than in either the autumn or the two previous winters (Figure 3.3.7). At Rhymney, mudflats to the west of the Cardiff Eastern Sewer held few Curlews, numbers were greatest on mudflats 14 and 15 to the east. Densities of Curlews in 1995/96 were low across both Rhymney and Orchard Ledges (Figure 3.3.8). In previous winters, Orchard Ledges and neighbouring mudflats of Rhymney had held the highest densities.

Peak numbers of Curlews at Taff/Ely occurred three hours before and three hours after high tide, following the pattern observed in autumn (Figure 3.3.9a). The winter peak mean was similar to that in autumn and those in previous winters. Peak mean numbers at the other two study sites were lower than those in autumn and in previous winters, however (Figure 3.3.9b and c).

The total usage of the three sites in winter has declined since 1992/93, having being relatively stable beforehand (r_s = -0.464, n = 7, ns; Figure 3.3.10). The usage of Cardiff Bay alone, however, was at its lowest in 1991/92. In 1995/96, the mean feeding usage density of Curlews at Cardiff Bay was greater than that at either Orchard Ledges or Rhymney (1.5 bird hours per tidal cycle per hectare, compared with 0.7 and 0.1 respectively).

Spring 1996

Very few Curlews remained at the study sites into spring. At Taff/Ely feeding birds were concentrated on mudflat 12 (Figure 3.3.11). Curlews were also recorded feeding at Orchard Ledges and on mudflats 13 and 14 at Rhymney (Figure 3.3.12).

A peak mean of 20 was recorded at Taff/Ely, with the majority continuing to roost on the mudflats after the high tide period (Figure 3.3.13a). Numbers here and at Orchard Ledges (Figure 3.3.13b) and Rhymney (Figure 3.3.13c) were higher than in the previous spring.

3.4 Redshank

An estimated 35-38,000 pairs of Redshanks breed in Britain and Ireland, mainly on wet grasslands and on coastal saltmarshes (Gibbons *et al.*, 1993). The British wintering population is formed of birds from both Britain and Ireland, and Iceland (Prater, 1981). A minimum population of 83,000 wintered on Britain's estuaries and shores in 1994/95 (Waters *et al.*, 1996). The Severn Estuary is internationally important for Redshanks in winter.

Autumn 1995

At Taff/Ely, several hundred Redshanks were present through the autumn and were seen feeding on most mudflats (Figure 3.4.1). The main areas of usage were adjacent to the River Taff in the centre and north of the study site. In the two previous autumns, Redshanks had been more concentrated along the upper mudflats of the River Taff and on those adjacent to the yacht club. No Redshanks were seen at Orchard Ledges. At Rhymney, several hundred birds were present in autumn and feeding activity was observed on most mudflats to the east of the Cardiff Eastern Sewer (Figure 3.4.2). Most feeding birds were present on the banks of the River Rhymney along mudflats 14-16. The distribution of Redshank was similar to that in the two previous autumns, although numbers were somewhat higher. The majority of the Redshanks observed in autumn are likely to remain at Cardiff for the winter. A small proportion, however, are likely to be birds on passage to other wintering areas.

At Taff/Ely, as the tide ebbed, Redshanks moved from their roosting areas in the saltmarsh onto the nearest mudflats. Initially feeding flocks were large and visible, but by low tide, many birds had moved out of sight, feeding in small numbers along creeks or on river banks. Most birds came back into view as the rising tide pushed them onto higher mudflats. There was a peak mean of over 170 birds at this time, a slightly lower figure than in the previous autumn (Figure 3.4.3a). Two clear peaks in numbers also occurred at Rhymney, two to three hours before and after low tide (Figure 3.4.3c). The birds were not seen to leave the site, and the apparent fall in numbers occurred when Redshanks moved onto lower areas of the river banks and out of sight from the observation points.

Winter 1995/96

Low tide counts of feeding Redshanks on the northwest Severn showed that the main areas occupied were at Taff/Ely and Rhymney, with just a few feeding birds being located at St Brides (Figure 3.4.4).

Feeding Redshanks were widely distributed at Taff/Ely and used almost all mudflats (Figure 3.4.5). Those adjacent to the River Taff held the highest numbers. The overall levels of usage were similar to those in autumn and the two previous winters. However, more Redshanks fed on mudflats 2 and 5, which were closest to the barrage work, than in autumn and than in winter 1994/95. In terms of density, mudflats 8, 9 and 10 on the upper River Taff and mudflats 15, 18 and 19 close to the yacht club were most important for Redshanks in this and the two previous winters (Figure 3.4.6). Larger mudflats close to the barrage, such as 2 and 5, held the lowest densities.

No Redshanks were seen at Orchard Ledges. At Rhymney, Redshanks were found on all sectors to the east of the Cardiff Eastern Sewer with the highest levels of usage occurring on mudflats 14, 15 and 16 (Figure 3.4.7). As in the autumn, the main feeding areas on these mudflats were adjacent to the river. The distribution of Redshanks at Rhymney was similar to previous winters. Densities of Redshanks were particularly low on the large mudflat 14, but high on mudflats 15 and 16 along the river (Figure 3.4.8).

The numbers of Redshanks observed at Taff/Ely and their behaviour during the tidal cycle were similar to those described for the autumn period (Figure 3.4.9a), although a higher proportion of the birds fed for longer periods. The number of Redshanks at Rhymney was higher than in autumn and the peak mean of 370 birds occurred two hours before low tide (Figure 3.4.9c). This figure was 20% higher than that for the previous winter. As in the autumn, many Redshanks at both sites were out of sight at low tide in creeks and along river banks.

The total usage of the three sites in winter has declined since 1989/90 (r_s = -0.714, n = 7, P = 0.10), although not consistently from year to year or between sites (Figure 3.4.10). The mean feeding usage density of Redshanks at Cardiff Bay was twice that at Rhymney (9.6 bird hours per tidal cycle per hectare, compared with 4.9), perhaps because the mudflats at Cardiff Bay are dissected by more creeks and rivers, where birds are able to feed.

Spring 1996

Redshank numbers declined during the late winter and by the beginning of spring, almost all birds had left for their breeding grounds. A maximum of 47 birds was seen at Taff/Ely in April, most of which were confined to the upper mudflats of the River Taff, but no birds were observed at the other two sites. Only one Redshank was observed in Cardiff Bay in May.

These observations are comparable to the findings of previous springs.

3.5 Other Species

3.5.1 Mallard *Anas platyrhynchos*

The Mallard is the most abundant wildfowl in Britain, but may have recently shown a decline in its wintering population (Cranswick *et al.*, 1995; Waters *et al.*, 1996). Large numbers of birds are found on inland sites and the population is boosted annually by the release of hand-reared birds for shooting. The Severn Estuary is nationally important for Mallards in winter.

Winter 1995/96

The majority of the feeding Mallards observed on the northwest Severn during low tide counts were located at the east of the study area, mainly on the eastern mudflat of Peterstone and on the lower mudflats of St Brides (Figure 3.5.1.1).

Taff/Ely supported small numbers of feeding Mallards. These were mainly found on mudflat 6 adjacent to the River Taff and on mudflat 18 along the eastern channel to the yacht club (Figure 3.5.1.2). The distribution of Mallards was less concentrated in the two previous winters, when birds used more mudflats in the centre of the bay. Mudflat 17 may have been avoided this winter due to work on the barrage.

No feeding Mallards were found at Orchard Ledges. At Rhymney, feeding birds were again found mainly along the edge of the river and only sectors bordering this freshwater were used at all (Figure 3.5.1.3).

There were few Mallards at both Taff/Ely and Rhymney, with peak means of 30-40 birds (Figures 3.5.1.4a and c). Typically, less than half of the population at either site fed at any one time.

The winter observations were very similar to those found during autumn. In spring, up to 12 Mallards were seen at Taff/Ely, two at Orchard Ledges and five at Rhymney.

3.5.2 Teal *Anas crecca*

The British breeding population of Teals is thinly distributed in areas throughout England, Scotland, Wales and Ireland. There has been a marked contraction in its range, however, over the last 20 years (Gibbons *et al.*, 1993). The wintering population, in contrast, has shown a general increase over the last 25 seasons (Cranswick *et al.*, 1995; Waters *et al.*, 1996). The Severn Estuary holds nationally important populations of Teal.

Winter 1995/96

At low tide the majority of feeding Teals on the northwest Severn were at the east of the study area, at St Brides. Smaller numbers occurred near the rivers Taff and Rhymney (Figure 3.5.2.1).

Feeding Teals at Taff/Ely were concentrated on mudflats along the upper River Taff and along the eastern channel to the yacht club. In the two previous winters, numbers were lower on the River Taff mudflats (Figure 3.5.2.2). Overall, however, there has been little change in the feeding distribution of Teals at Taff/Ely since 1991/92. In that winter, high levels of usage occurred on mudflats 1 and 2, near the mouth of the study site.

Lower levels of usage were found at Rhymney, with the Teals confining themselves to the banks of the river, east of the Cardiff Eastern Sewer (Figure 3.5.2.3). No Teals were seen at Orchard Ledges.

The peak mean numbers of Teals at Taff/Ely and Rhymney were 63 and 25 birds respectively (Figure 3.5.2.4a and c). The figure for Taff/Ely was only 70% of that for the previous winter. There was no clear pattern in feeding or presence on the mudflats and many birds were not included in counts as they spent a lot of time roosting on the open water.

Only small numbers of Teals had returned to Taff/Ely during the autumn, and no birds were recorded at the other two sites during this period. By the end of the winter period, all of the Teals had moved away from the study area.

3.5.3 Pintail *Anas acuta*

The Pintail is a rare and local breeding bird in Britain (Gibbons *et al.*, 1993). This species colonised Britain in the late nineteenth century and since 1973, at least, the British and Irish breeding population has been relatively stable (Fox & Meek, 1993). Breeding birds from northwest Europe move south in autumn and a minimum of 22,000 wintered in Britain in 1994/95 (Waters *et al.*, 1996). The wintering population declined a number of years ago and remains low. The Severn Estuary holds nationally important numbers of Pintails.

Winter 1995/96

The highest densities of feeding Pintails observed during low tide counts on the northwest Severn were on mudflats near to the River Rhymney at Peterstone and Rhymney (Figure 3.5.3.1). Few birds were seen elsewhere. This pattern is consistent with that observed during previous winters.

No Pintails were seen at Taff/Ely or Orchard Ledges during the winter period. At Rhymney, feeding Pintails were present along the tide line, mainly to the east of the Cardiff Eastern Sewer (Figure 3.5.3.2). Birds were observed to move onto the study area from the east as the tide ebbed and remained at the water's edge to feed. Pintails moved onto mudflats higher up the intertidal zone as the tide flooded. Levels of usage on mudflats to the west of the Cardiff Eastern Sewer have increased over the last three winters.

Most of the birds at Rhymney arrived three hours before low tide, when the lower intertidal became exposed, remaining there until these areas again became covered on the rising tide (Figure 3.5.3.3c). The majority of Pintails fed at this time.

Small numbers of Pintails had returned to Rhymney by late autumn, but all had left before the spring study period.

3.5.4 Pochard *Aythya ferina*

Pochards have bred in Britain since the last century, but are still only present in low numbers (Gibbons *et al.*, 1993). Although the wintering population, as estimated by the Wetland Bird Survey, has shown a decline since the late 1980s, the minimum of 39,000 birds in 1994/95 was an increase on the previous year (Waters *et al.*, 1996). The Severn Estuary holds nationally important numbers of wintering Pochards.

Winter 1995/96

Small numbers of feeding Pochards were present on the northwest Severn during low tide counts, near the Rivers Taff and Rhymney and at Peterstone (Figure 3.5.4.1). Larger numbers of Pochards were present at times near to the mouth of the River Rhymney, but many of these birds remained on the open water.

Very few Pochards fed at Taff/Ely and none were observed at Orchard Ledges. Although many were present within Cardiff Bay on count days, these birds usually roosted on the open water. At Rhymney, Pochards were present at the mouth of the river on mudflats 9 and 11 (Figure 3.5.4.2). There have been an increasing number of Pochards feeding on the River Rhymney since 1991/92.

The peak mean of 15 Pochards recorded an hour before low tide at Rhymney was only 30% of the figure for 1994/95 (Figure 3.5.4.3c). Many fewer birds were present earlier in the tidal cycle.

Pochards were only present during the winter.

3.5.5 Oystercatcher

A population of 36-47,000 pairs of Oystercatchers breed in Britain and Ireland, occupying both inland and coastal sites (Piersma, 1986; Gibbons *et al.*, 1993). In autumn and winter, the number of birds increases with the influx of migrants from northern Europe. A minimum population of 237,000 wintered on the estuaries and coasts of Britain in 1994/95 (Waters *et al.*, 1996). The Severn Estuary is not an important wintering site.

Winter 1995/96

Feeding Oystercatchers were found on most parts of the northwest Severn during low tide counts, the largest numbers being present at Rhymney and Peterstone (Figure 3.5.5.1).

Small numbers of feeding Oystercatchers were present at Taff/Ely, mainly on mudflats to the south and west of the River Taff, where usage was higher than in the two previous winters (Figure 3.5.5.2). Oystercatchers typically used the bay shortly before and shortly after high tide, but moved away over low water to Orchard Ledges.

Much larger numbers of feeding Oystercatchers were present at Orchard Ledges and Rhymney (Figure 3.5.5.3). Birds moved onto the Orchard Ledges mudflats from their high tide roosts, to the east of Rhymney and in Cardiff Bay, as soon as the shore became uncovered. Numbers here were higher than in the two previous winters. At Rhymney, all mudflats were used by feeding Oystercatchers. Large numbers of birds moved to the lower shore as the tide ebbed and continued to feed as new mudflats were exposed. The highest numbers of feeding birds were found on mudflats 13 and 14. More Oystercatchers used mudflats along the river, particularly mudflat 10, than in the two previous winters.

Numbers of Oystercatchers at Taff/Ely peaked before they had moved to Orchard Ledges, four hours before low tide and again four hours afterwards, when Orchard Ledges was again flooded (Figure 3.5.5.4a). Not all of these birds remained to roost in the bay, however. At Orchard Ledges numbers peaked shortly before and shortly after low tide (Figure 3.5.5.4b). At Rhymney numbers were relatively stable over the low tide period with a peak mean of 190 birds (Figure 3.5.5.4c).

Oystercatchers return from their breeding grounds early and were present at all three study sites during the autumn. Their numbers and feeding distribution were similar to that described for winter. By spring, there were almost no Oystercatchers at Taff/Ely, and the Orchard Ledges and Rhymney populations were reduced to about a third of their winter values.

3.5.6 Ringed Plover *Charadrius hiaticula*

The majority of the British and Irish breeding population of almost 10,000 pairs of Ringed Plovers is found on coastal sites, but increasingly breeding birds are found on suitable inland areas (Gibbons *et al.*, 1993). Many of these birds winter around the estuaries and coast of Britain, where there is an estimated population of 28,600 (Cayford & Waters, 1996). There is evidence for a decline in the numbers of Ringed Plovers on non-estaurine sites in winter (Browne *et al.*, 1996). The Severn Estuary does not hold nationally important numbers of this species.

Winter 1995/96

Only occasional Ringed Plovers were observed during low tide counts of the northwest Severn and their distribution, therefore, is not mapped.

Similarly, only a few feeding Ringed Plovers were present at Taff/Ely on all day counts and therefore their distribution is not mapped. At Orchard Ledges, Ringed Plovers were very difficult to detect, unless they were near to the shore and actively feeding, because of the nature of the substrate. Feeding birds were only observed on mudflat 1 (Figure 3.5.6.1). Small numbers of Ringed Plovers sometimes roosted over the high tide period on the shingle shore near mudflat 17 at Rhymney. These moved onto the mudflat to feed as the tide receded, fed elsewhere for most of the tidal cycle and returned to feed briefly just before the area was again covered (Figure 3.5.6.1).

The numbers of Ringed Plovers on the study sites was small. At Rhymney numbers peaked shortly before and shortly after high tide, when birds were still in the upper intertidal zone (Figure 3.5.6.2b).

Small groups of Ringed Plovers were seen at the three study sites during the autumn period, but by spring, only one small group was noted at Orchard Ledges.

These findings are similar to those reported during the previous study years.

3.5.7 Grey Plover *Pluvialis squatarola*

The British wintering population of Grey Plovers originates mainly from breeding areas between the White Sea and the Taimyr Peninsula in Russia (Prater, 1981). There has been a steady increase in numbers over recent winters and there was a minimum population of 49,000 in 1994/95 (Waters *et al.*, 1996). The Severn Estuary holds nationally important numbers of wintering Grey Plovers.

Winter 1995/96

Feeding Grey Plovers were found on several sections during low tide counts on the northwest Severn (Figure 3.5.7.1). The main groups were on St Brides.

Several small groups of feeding Grey Plovers were seen at Taff/Ely, with a peak mean of seven birds. Their presence was irregular and they usually only remained for one to two hours. No birds were seen at either of the other two study sites during the winter period.

Grey Plovers were not present at the study sites during autumn and spring.

This species has been regularly recorded at Taff/Ely, and during the earlier winters larger numbers were observed. The population of wintering Grey Plovers has always been too small to be important.

3.5.8 Lapwing *Vanellus vanellus*

A population of 205-260,000 pairs of Lapwings breed in the British Isles (Gibbons *et al.*, 1993). Many of these birds move to the continent to winter, but numbers in Britain and Ireland are increased at this time by arrivals from Scandinavia and eastern Europe (Prater, 1981). Large numbers of wintering Lapwings are located on both estuaries and inland sites (Waters *et al.*, 1996) and the Severn Estuary holds nationally important numbers of this species.

Winter 1995/96

Although large flocks of Lapwings are present in the area, the majority of birds remain inland to feed and roost. Groups of feeding Lapwings were observed on the northwest Severn on low water counts at St. Brides and at Taff/Ely (Figure 3.5.8.1).

At Taff/Ely feeding Lapwings were present on mudflats 8, 9 and 10 along the upper River Taff (Figure 3.5.8.2). This distrbution was similar to that of the two previous winters. Lapwings only spent part of their time feeding while on these mudflats. No Lapwings were seen at Orchard Ledges. At Rhymney feeding Lapwings were confined to mudflat 16 (Figure 3.5.8.3).

The number of Lapwings at these sites is small compared with the size of many inland wintering flocks. At Taff/Ely, there was a peak mean of over 50 birds after low tide (Figure 3.5.8.4a). At Rhymney, Lapwing numbers peaked shortly before and shortly after high tide (Figure 3.5.8.4c). At both sites, spells of feeding activity were interspersed with long spells of inactivity.

Only very small numbers of Lapwings were present at the study sites during autumn, and by spring, all of the birds had left.

3.5.9 Knot *Calidris canutus*

The British wintering population of Knots originate from breeding areas in northern Greenland and north-eastern Canada (Prater, 1981). A minimum of 246,000 Knots wintered in Britain in 1994/95 (Waters *et al.*, 1996). The Severn Estuary is not a nationally important wintering site.

Winter 1995/96

Knots are less site-faithful than many other waders and may change their wintering sites regularly (Pienkowski & Clark, 1979; Dugan, 1981). In consequence of this, the numbers of Knots seen on the northwest Severn during low tide counts have varied considerably over the seven year study period. In the winter of 1995/96, the only large groups of feeding Knots were found at Rhymney and on the boundary between St. Brides and Peterstone (Figure 3.5.9.1).

Very few feeding Knots were present at Taff/Ely during all day counts in the winter of 1995/96. Larger flocks of feeding birds were present at Rhymney and these were seen mainly on mudflats 10 and 11 adjacent to the river (Figure 3.5.9.2). Numbers at Rhymney have declined considerably over the last three winters, however. Knot usually arrived at Rhymney towards low tide and were often associated with Dunlins or Redshanks (Figure 3.5.9.3c).

No Knots were present at the three study sites during the autumn or spring periods.

3.5.10 Turnstone *Arenaria interpres*

The British wintering population of Turnstones originates from breeding areas in Greenland and Canada (Prater, 1981). The majority winter on open coasts, particularly on rocky shores, where their numbers have been estimated to have declined by 44% between 1984/85 and 1994/95 (Browne *et al.*, 1996). The British wintering population has been estimated at 64,400 birds (Cayford & Waters, 1996). The Severn Estuary is not a nationally important site.

Winter 1995/96

Feeding Turnstones were found on low tides counts of the northwest Severn at the western end of Rhymney, i.e. the stony area of Orchard Ledges (Figure 3.5.10.1). Apart from a few other very small areas, most of the northwest Severn mudflats are unsuitable for feeding Turnstones.

Feeding Turnstones were recorded regularly at Taff/Ely, but only along the stony edge of mudflat 3 and on mudflat 10 (Figure 3.5.10.2). Turnstones typically arrived in this area three hours after low tide as Orchard Ledges was covered by the rising tide. On some days Turnstones stayed at the edge of mudflat 3 over the high tide period and then left the bay on the falling tide. Orchard Ledges supported many more feeding birds (Figure 3.5.10.3). Small numbers of Turnstones were also found at Rhymney mainly on mudflats 17, 16 and 15. The distribution of Turnstones at these sites was similar to that in the two previous winters.

The peak mean number of almost 80 birds at Orchard Ledges occurred an hour before low tide (Figure 3.5.10.4b). At Rhymney, there were two clear peaks of over 20 birds, shortly before and shortly after high tide (Figure 3.5.10.4c).

Small numbers of Turnstones were present at the three sites during the autumn, following the pattern of behaviour described for the winter period. By the spring, almost all Turnstones had left the study area.

3.6 Other Wildfowl and Wader Sightings

Several other species of wildfowl and waders were observed at the Taff/Ely and Rhymney sites but in numbers too small to be included in the separate species accounts. These are shown in Table 3.6.1. Of particular note are the 22 Scaups *Aythya marila* seen in March 1996 at Rhymney.

4. DISCUSSION AND CONCLUSIONS

The continuing monitoring of the wader and wildfowl populations of Cardiff Bay and the northwest Severn has built a picture of the distributions and movements of the major species which winter in the area. The distribution of many species has changed from year to year, either in response to disturbance from work in the bay or to changing food supplies. Populations also change annually as survival and recruitment rates vary. The long-term monitoring programme will provide an understanding of the 'natural' population and distributional changes of the waterfowl and thus allow the future impact of the inundation of the bay to be more fully determined.

Construction work began at the mouth of the bay in 1994 and by spring 1996, the eastern and western sides of the barrage had been built and connected with a bridge. This work is continuing to affect the distributions and numbers of birds using the bay as a wintering area. It will be essential to obtain a clear picture of any such changes to these populations during this phase if it is to be possible to assess the effect of the Cardiff Bay barrage on waders and wildfowl.

The recent changes in the distribution and abundance of the waterfowl of the area, as shown by all day counts, are discussed below.

Shelduck (no obvious disturbance effect)

The small population of Shelducks present at Rhymney during autumn 1995 was greater than that seen in either of the previous two autumns, but was similarly distributed. Likewise, there were higher numbers at this site during winter 1995/96 than in either of the previous two winters. In contrast, the distribution and number of wintering Shelducks at Taff/Ely have not changed and seem unaffected by the building of the barrage. Similar numbers of Shelducks remained into spring as in previous years.

Dunlin (possible disturbance effect)

There were fewer Dunlins at Rhymney during autumn 1995 than in previous autumns. Likewise, there were fewer Dunlins at both this site and at Taff/Ely during the winter of 1995/96 than in either of the previous two winters. For the second year, the levels of usage of mudflats 3, 4 and 5 at Taff/Ely were particularly low, possibly a result of disturbance from the building of the barrage. At Rhymney, usage levels were low on mudflats 1 to 9 at the west of the site.

Curlew (likely disturbance effect)

In comparison to previous autumns at Taff/Ely, fewer Curlews used mudflat 2 close to the mouth of the bay. This mudflat had been reduced by dredging and also, was disturbed by the building of the barrage. Mudflats 6, 17 and 18, perhaps in consequence, had increased levels of usage. In winter, however, mudflat 2 had the highest level of usage, in spite of continuing work. Levels of usage at both Orchard Ledges and Rhymney during winter were lower than in the previous two winters.

Although the total usage of the three sites has declined since 1992/93, the level of usage of Cardiff Bay was at its lowest in 1991/92. This was perhaps due to disturbance from the construction of the PDR and in that winter the use of Orchard Ledges declined sharply too. At Rhymney, however, site usage was high, suggesting that birds had moved there from the other two sites and that this site was not at its carrying capacity in previous or, indeed, subsequent winters.

Redshank (likely disturbance effect)

As with Curlews, many more Redshanks used mudflats 2 and 5 close to the barrage in the winter of 1995/96 than in autumn or than in the previous two winters. This was in spite of continuing noise from

work on the barrage nearby and suggests a degree of habituation to this disturbance. The population of Redshanks at Rhymney was higher than in the previous winter, but was similarly distributed.

Other species

Numbers of Teals at Taff/Ely during winter 1995/96 were 30% lower than in 1994/95. Their feeding distribution has not changed significantly, however, and the species was not thought to have been affected by the building of the barrage.

Pochard numbers have declined sharply at all sites and very few now feed in the bay. The species is becoming increasingly confined to the River Rhymney during winter.

The numbers of two species of wader have also changed: Oystercatcher have increased at Orchard Ledges, whilst Knot have declined at Rhymney. Only small changes were seen in the numbers and distribution of Mallards, Pintails, Ringed Plovers, Golden Plovers, Lapwings and Turnstones.

To summarize, the work on the barrage at the mouth of the bay has had some effect on the numbers and distribution of, in particular, Curlews and Redshanks. This distributional effect, however, was more noticeable in autumn than in winter. Continued monitoring in 1996/97 will determine if the work has continued to cause disturbance and will enable us to further assess the recovery rate of waterfowl communities after disturbance events.

PART 2: STUDIES OF THE WINTERING ECOLOGY OF REDSHANK

5. INTRODUCTION

Waders vary in their site-fidelity both between and within winters (Symonds *et al.*, 1984; Rehfisch *et al.*, 1996). Some species, such as Knot, commonly change their wintering grounds between winters (Pienkowski & Clark, 1979; Dugan, 1981), whilst many, for example, Curlew (Bainbridge & Minton, 1978), Green Sandpiper *Tringa ochropus* (Smith *et al.*, 1992), Turnstone and Purple Sandpiper *Calidris maritima* (Burton & Evans, in press), return to the same area each year and stay there throughout winter. The degree of site-fidelity shown by different species is largely a result of the temporal stability and predictability of their food resources (Evans, 1981). Sanderling *Calidris alba*, for example, may move between a number of sites within a winter because of the less predictive nature of their food supplies (Evans, 1981; Myers, 1984; Roberts, 1991).

In order to understand the impact of the loss of Cardiff Bay to any given species it is important to have a knowledge of the site-fidelity of that species (Goss-Custard, 1985). More mobile species, which are less reliant on the food resources of the bay, may be better able to cope with its loss. This chapter discusses preliminary results of studies on the site-fidelity of Redshanks. Over 200 Redshanks are found in Cardiff Bay in winter and over 300 at Rhymney. The species has been found to be particularly site-faithful to wintering grounds in other studies (Furness & Galbraith, 1980; Cresswell & Whitfield, 1994; Rehfisch *et al.*, 1996; Insley *et al.*, in press) and may, therefore, be at particular risk from the loss of the bay and its intertidal feeding areas.

Studies of the over-summer return rates of Redshanks to the study area (i.e. Cardiff Bay, Orchard Ledges and Rhymney) and their winter survival rates will help to determine whether the loss of the bay results in increased mortality in the population. Previous studies have shown that annual survival is high (Thompson & Hale, 1993; Insley *et al.*, in press), although this may vary between years and sites according to weather conditions and predation pressure (Cresswell & Whitfield, 1994; Insley *et al.*, in press). Redshanks suffer particularly high mortality in cold winters (Davidson & Evans, 1982). Additional analysis of the patterns of seasonal mass change in Redshanks prior to and following the flooding of the bay will help to determine whether their body condition was adversely affected by the loss of the bay and its food resources. As with other waders, Redshanks have been found to increase their mass in midwinter prior to the coldest winter weather (Johnson, 1985; Norman & Coffey, 1994).

6. METHODS

6.1 Movement Studies

During winter 1995/96, samples of Redshanks were caught either by mist- or cannon-netting at high tide roosts at both Cardiff Bay and Rhymney. Each bird caught was aged according to its plumage characteristics (Prater *et al.*, 1977) as either an adult or a first-winter bird and the majority of adults then given an unique combination of Darvic plastic colour-rings for subsequent identification in the field. A total of 50 adult Redshanks were colour-ringed at Cardiff Bay on six catches between late October and February (Table 6.1.1). In addition, six adult Redshanks controlled at Rhymney, but originally fitted with metal rings at Cardiff Bay, were also colour-ringed (Table 6.1.1). A total of 88 Redshanks were given individual combinations of colour-rings in winter 1994/95 (Toomer *et al.*, 1995) and many more previously 'scheme-marked' with just yellow and white rings for identification as Cardiff Bay birds.

In order to understand the movements of Redshanks during winter, both Cardiff Bay and Rhymney were searched regularly for colour-ringed individuals (Redshanks have never been recorded at Orchard Ledges). In addition, the percentage of colour-ringed birds in samples of the population was recorded at both Cardiff Bay and Rhymney whenever possible. Sightings from further afield, made throughout the year, are also reported, together with details of Redshanks controlled in the study area.

6.2 Survival

Sightings of colour-ringed Redshanks also provide the basis for calculating survival rates for the species (see Metcalfe & Furness, 1985; Burton & Evans, in press). A minumum annual survival rate will be calculated from March 1996 to March 1997 and will be subdidvided into an over-summer 'return rate' (1 March to 30 September, covering migrations from and back to the study area and the breeding season) and a winter survival rate (1 October to 28 February). The survival or return rate will be calculated as the proportion of colour-ringed individuals seen alive at the start of a period that were known to be alive in the study area at the end of that period. (Minimum annual survival is calculated as the product of the over-summer return rate and the subsequent winter survival rate). Actual annual survival will be higher than the figure calculated if some individuals do not return to the study area after the breeding season.

6.3 Mass Changes

The mass of all Redshanks caught during the study period was recorded to the nearest 1 g with a Pesola balance. Data were available from 10 catches, from 28 October 1995 to 14 February 1996.

7. RESULTS

7.1 Movement Studies

A total of 157 sightings of individually colour-ringed Redshanks were made in the study area between October 1995 and March 1996. The majority of these were from Cardiff Bay, only 17 came from Rhymney. In all 85 individuals were identified, 72 exclusively at Cardiff Bay, six exclusively at Rhymney and seven at both sites. Those seen at Rhymney were all originally colour-ringed at Cardiff Bay. Five of the 12 Redshanks colour-ringed at Rhymney were seen at Cardiff Bay.

Estimates of the percentage of colour-ringed Redshanks in the population at each site are given in Table 7.1.1. The estimated percentage at Cardiff Bay increased over winter from a minimum of 4% to a maximum of 56% - a reflection of the continued ringing of birds during this period. Only a small percentage of the Redshank population at Rhymney was colour-ringed, though this too increased over winter.

An additional nine sightings of Redshanks colour-ringed in Cardiff were reported from elsewhere in Britain and Ireland during the study period (Table 7.1.2), most probably involving breeding birds. A nestling ringed at Repton in Derbyshire on 27 May 1994 was also controlled in Cardiff Bay in 19 December 1995.

7.2 Survival

Thirty-eight adult Redshanks seen in March 1996 will form the sample from which an over-summer return rate will be calculated for 1996. Of these, 35 were seen exclusively at Cardiff Bay and three at both Cardiff Bay and Rhymney. At the time of writing, 25 (66%) of these 38 birds have been seen at Cardiff since 1 October 1996.

7.3 Mass Changes

The masses of Redshanks in the study area varied over winter (Figure 7.3.1). Birds were lightest in October and early November and were heaviest in December.

8. DISCUSSION

It is now well-known that Redshanks are highly faithful both to their breeding grounds (Thompson & Hale, 1989, 1993; Zhmud, 1992; Jackson, 1994) and to their wintering grounds. A high proportion of birds return to the same wintering site each year and birds remain faithful to these sites within winter (Furness & Galbraith, 1980; Cresswell & Whitfield, 1994; Rehfisch *et al.*, 1996; Insley *et al.*, in press). Cresswell and Whitfield, for example, reported that 36 of 47 Redshanks colour-ringed one winter returned to the same site in Scotland the following winter. Insley *et al.* (in press) reported that, within winter, 65% of 3656 retraps of adult Redshanks were made at the same roost site. Annual survival is high, Insley *et al.* (in press) calculating a rate of 67% for Redshanks between their second and third winters, though a rate of just 43% for Redshanks between their first and second winters. Thompson & Hale (1993) reported rates of 75% and 72% for males and females respectively. There has been little study, however, of over-summer return rates to wintering sites and winter survival rates. Cresswell & Whitfield (1994) found that 31-57% of Redshanks were taken by raptors at their study site in Scotland between September and March, but did not calculate an overall winter mortality rate.

In the present study, it is apparent that there is considerable fidelity to Cardiff Bay both between and within winters, although actual return and survival rates have yet to be calculated. It is also clear, however, that there is some movement between Cardiff Bay and Rhymney within winter, 8% of colour-ringed individuals seen being recorded at both sites. More intensive study of colour-ringed birds and their movements is being made in the 1996/97 winter and will allow accurate calculation of over-summer return rates, winter survival rates and an assessment of their within winter site fidelity to Cardiff Bay.

Acknowledgements

Funding by Cardiff Bay Development Corporation has allowed the continuing study of the waterfowl of Cardiff Bay.

Thanks are due to members of local ringing groups for their help in the catching, ringing and colour-marking of waders.

The discussion of parts of this project with other members of the BTO staff was of considerable value.

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	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
Taff/Ely										
Canada Goose *Branta canadensis*					1					
Wigeon *Anas penelope*										1
Gadwall *Anas strepera*								2		
Shoveler *Anas clypeata*						1				
Ruddy Duck *Oxyura jamaicensis*							4			
Black-tailed Godwit *Limosa limosa*								5	9	
Bar-tailed Godwit *Limosa lapponica*		1								2
Whimbrel *Numenius phaeopus*									1	2
Common Sandpiper *Actitis hypoleucos*										1
Orchard Ledges										
Eider *Somateria mollissima*									1	
Bar-tailed Godwit										2
Whimbrel	1									
Rhymney										
Wigeon							10	2		
Shoveler						2	1			
Scaup							10	22		
Eider										1
Common Scoter *Melanitta nigra*									7	
Black-tailed Godwit					1	2		2		
Bar-tailed Godwit							1		1	
Whimbrel									5	2

Table 3.6.1 The maximum numbers of other wildfowl and waders seen at Cardiff during all day counts, 1995/96.

Date	Site	Number colour-ringed
28/10/95	Rhymney	5
30/10/95	Cardiff Bay	3
18/11/95	Cardiff Bay	2
7/12/95	Rhymney	1
12/12/95	Cardiff Bay	19
19/12/95	Cardiff Bay	11
2/1/96	Cardiff Bay	1
14/2/96	Cardiff Bay	14

Table 6.1.1 Dates of colour-ringing at Cardiff Bay and at Rhymney during winter 1995/96.

Date	Site	Percentage colour-ringed (n)	Sample size
13/11/95	Cardiff Bay	23.4 (39)	167
14/11/95	Cardiff Bay	43.2 (16)	37
19/1/96	Cardiff Bay	20.0 (2)	10
22/1/96	Cardiff Bay	10.5 (2)	19
7/2/96	Cardiff Bay	55.9 (33)	59
12/2/96	Cardiff Bay	54.3 (25)	46
13/2/96	Cardiff Bay	53.0 (61)	115
13/11/95	Rhymney	4.0 (4)	100
8/2/96	Rhymney	6.8 (7)	103
11/2/96	Rhymney	8.1 (19)	233

Table 7.1.1 Estimates of the percentages of colour-ringed birds in the Redshank populations at Cardiff Bay and Rhymney from November 1995 to February 1996.

Individual or scheme colour-ringing	Ring number	Date ringed	Dates observed	Location
Scheme			10/5/95	Lady's Island, Co. Wexford, Eire
Scheme			10/7/95	Marshside RSPB Reserve, Cheshire
Scheme			5/4/96	Willington, Derbyshire
Scheme			14/4/96	Dyfi Estuary, Dyfed
Scheme			22/4/96	R. Lune, Lancashire
Individual	DN54904	12/12/95	26/4/96	Shapwick Heath, Somerset
Individual	DN54908	19/12/95	6/5/96	Conwy, Gwynedd
Individual	DR96418	19/12/95	31/5/96	Balephetrish Bay, Tiree, Strathclyde
Individual	DN54788	12/12/95	25/5/96, 5/6/96 & 14/6/96	Lunedale, Co. Durham

Table 7.1.2 Sightings of Redshanks colour-ringed at Cardiff reported from elsewhere during the study period.

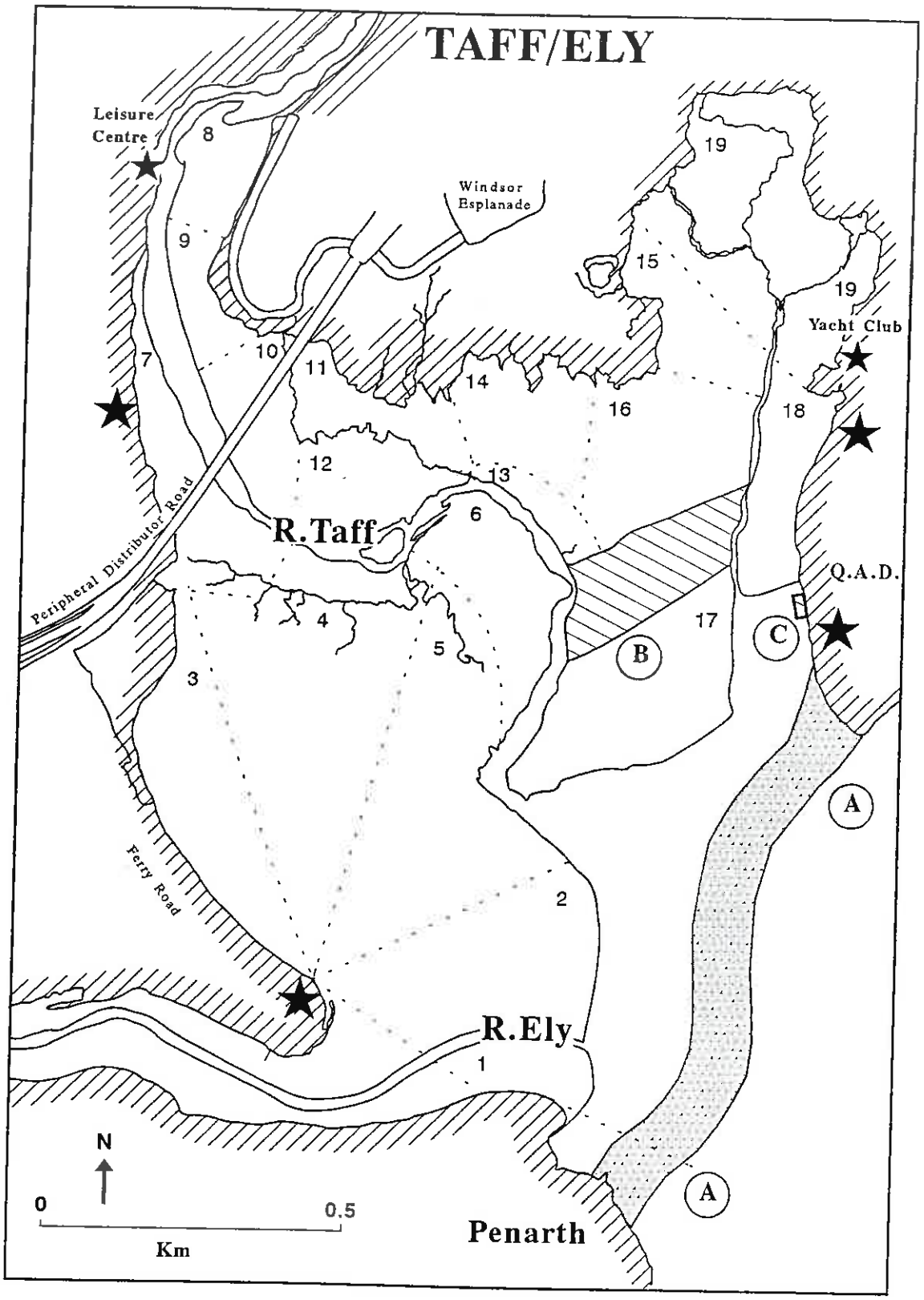

Figure 2.1.1 The Taff/Ely study site showing numbered mudflat count areas. Observation points are marked with an asterisk. Q.A.D. = Queen Alexandra Dock;

(A) = Beginning of barrage bank

(B) = Area of dredging

(C) = Temporary jetty

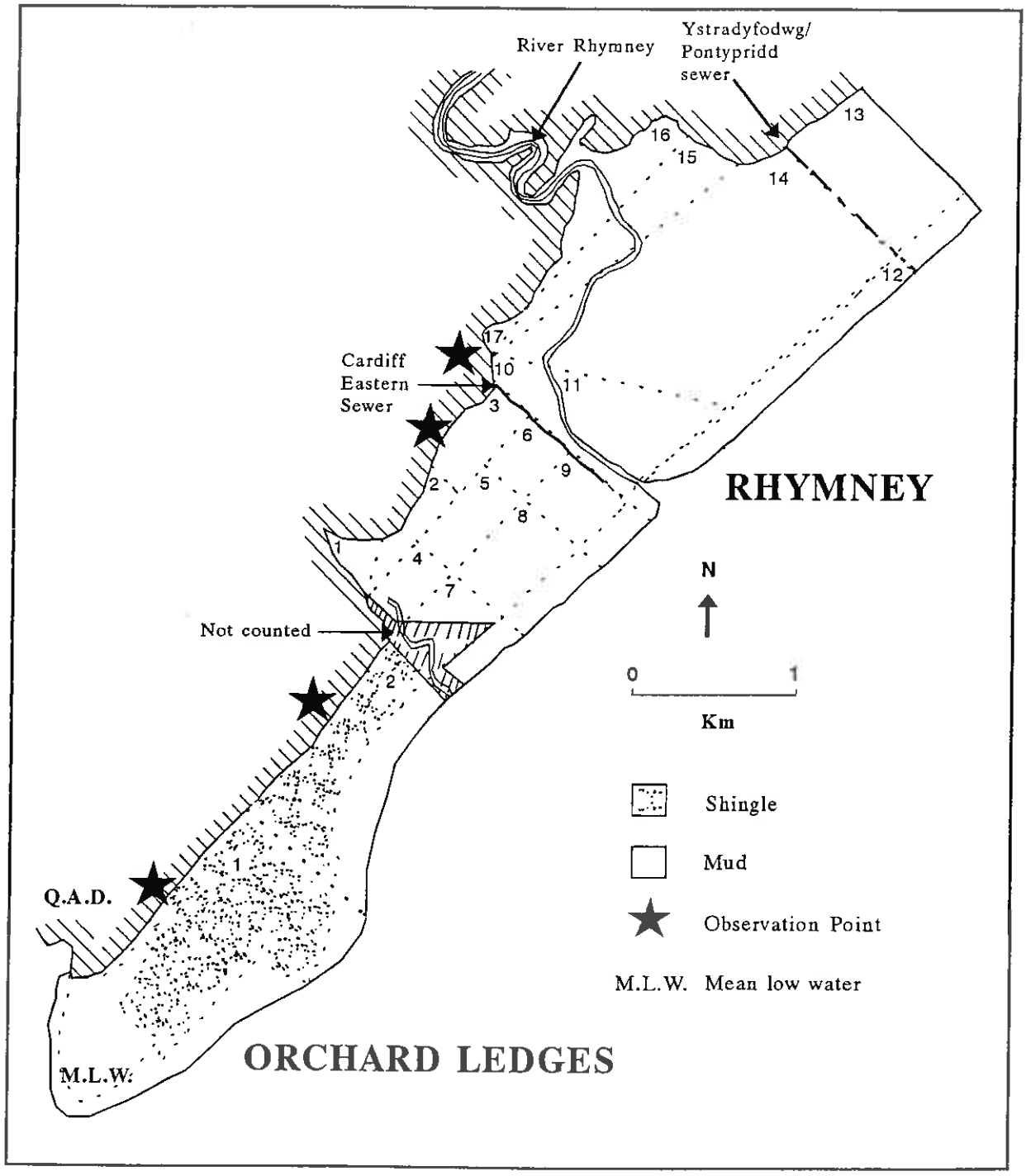

Figure 2.1.2 The Rhymney and Orchard Ledges study sites showing numbered mudflat count areas. Observation points are marked with an asterisk.

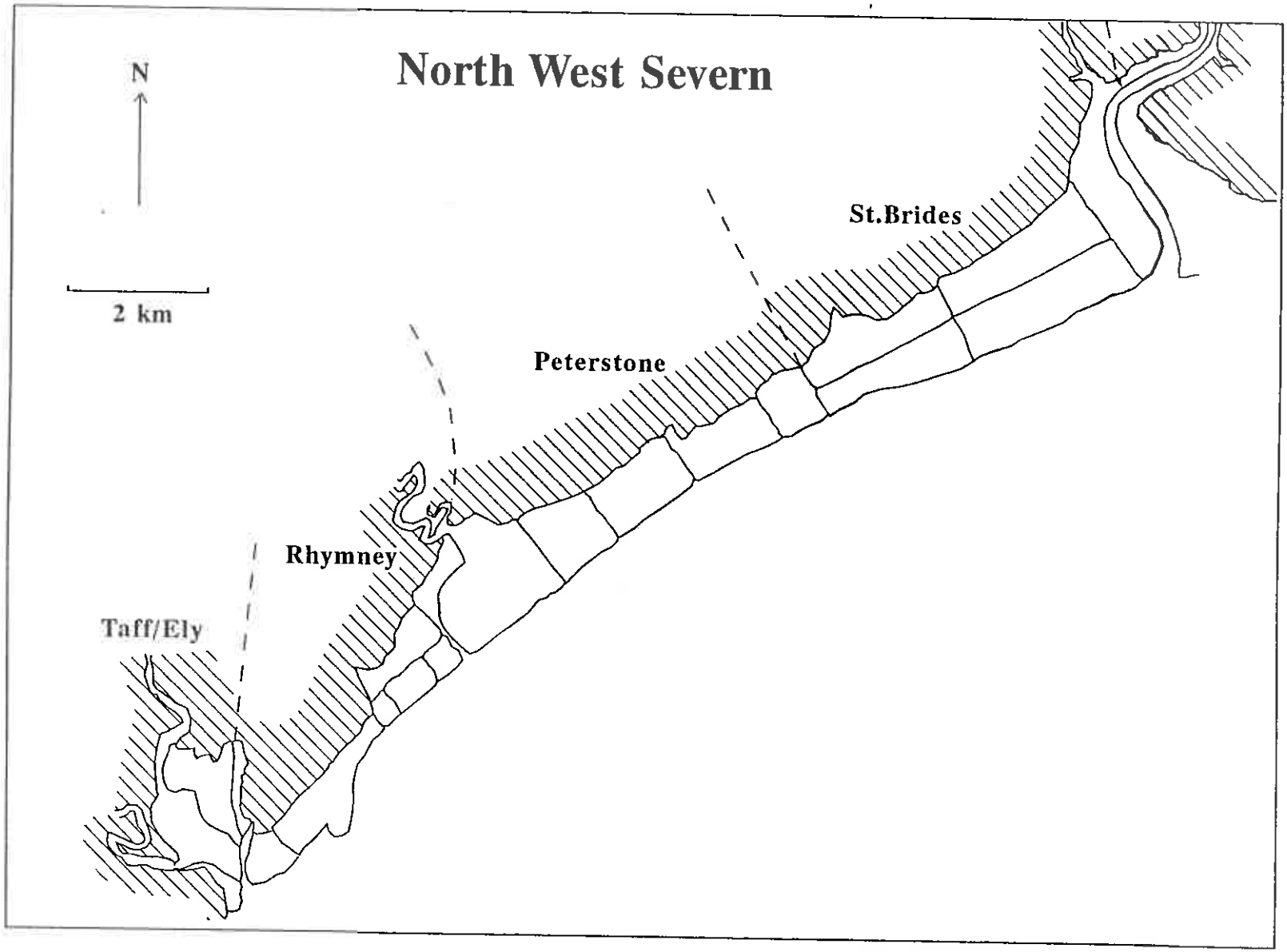

Figure 2.2.1 The breakdown of low tide count areas on the northwest Severn.

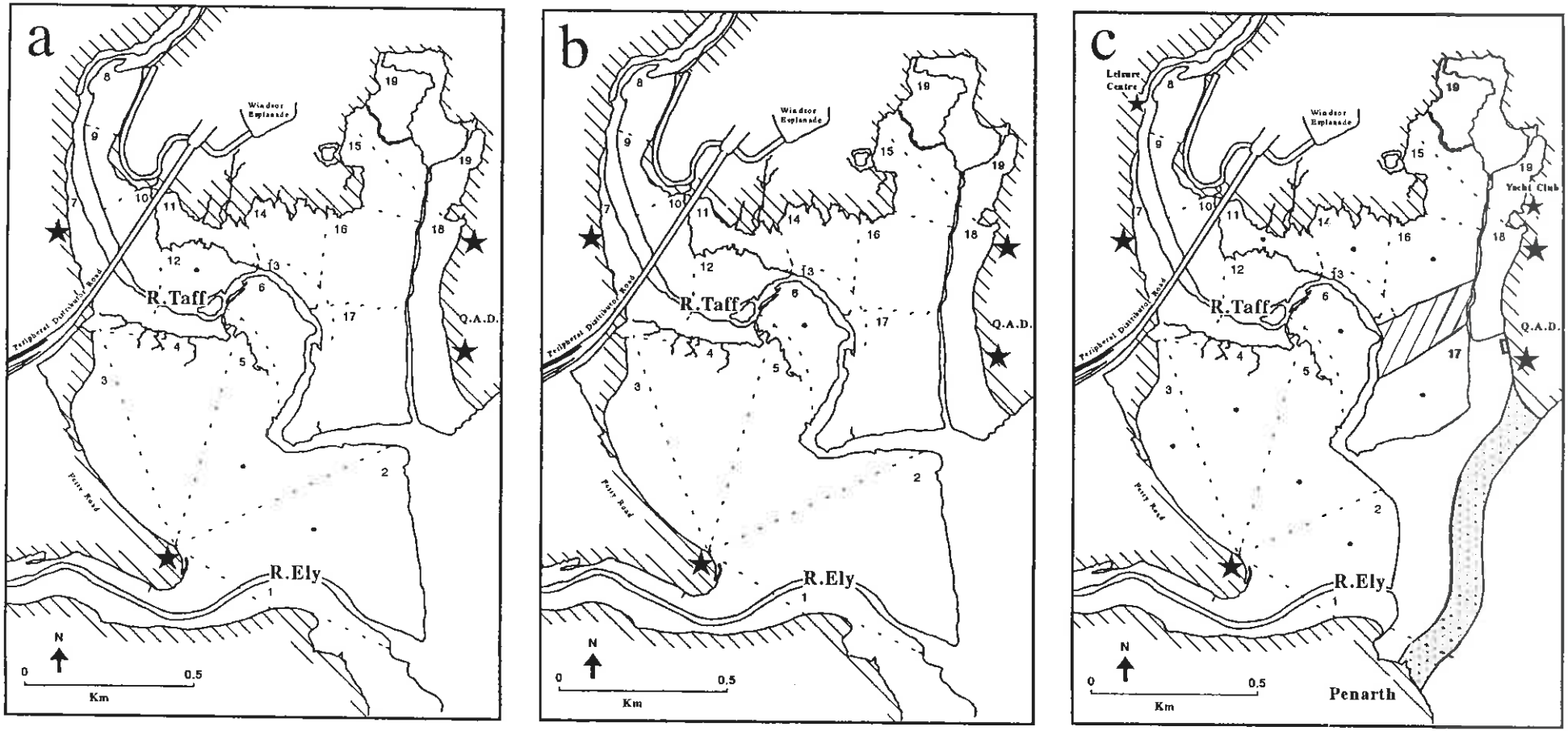

Figure 3.1.1
The distribution of feeding Shelduck on the Taff/Ely all day site during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-24	·	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

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1997

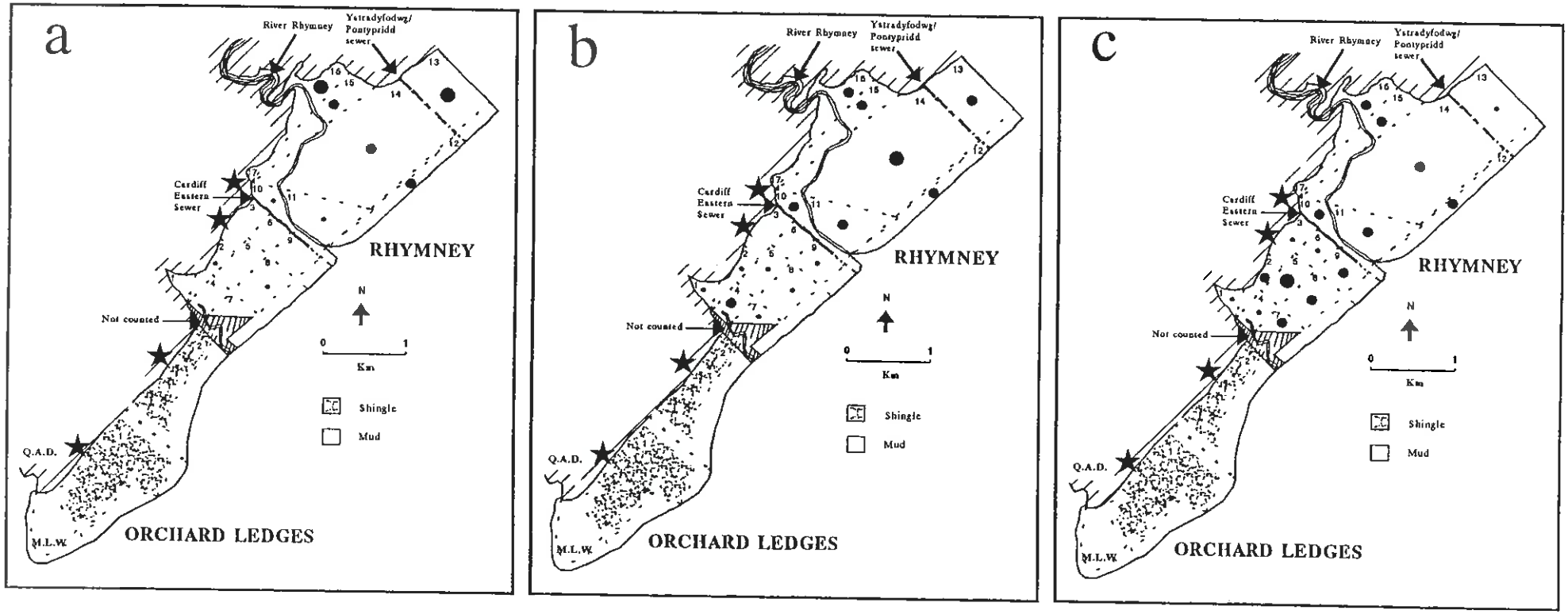


Figure 3.1.2
The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day sites during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-24	·	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

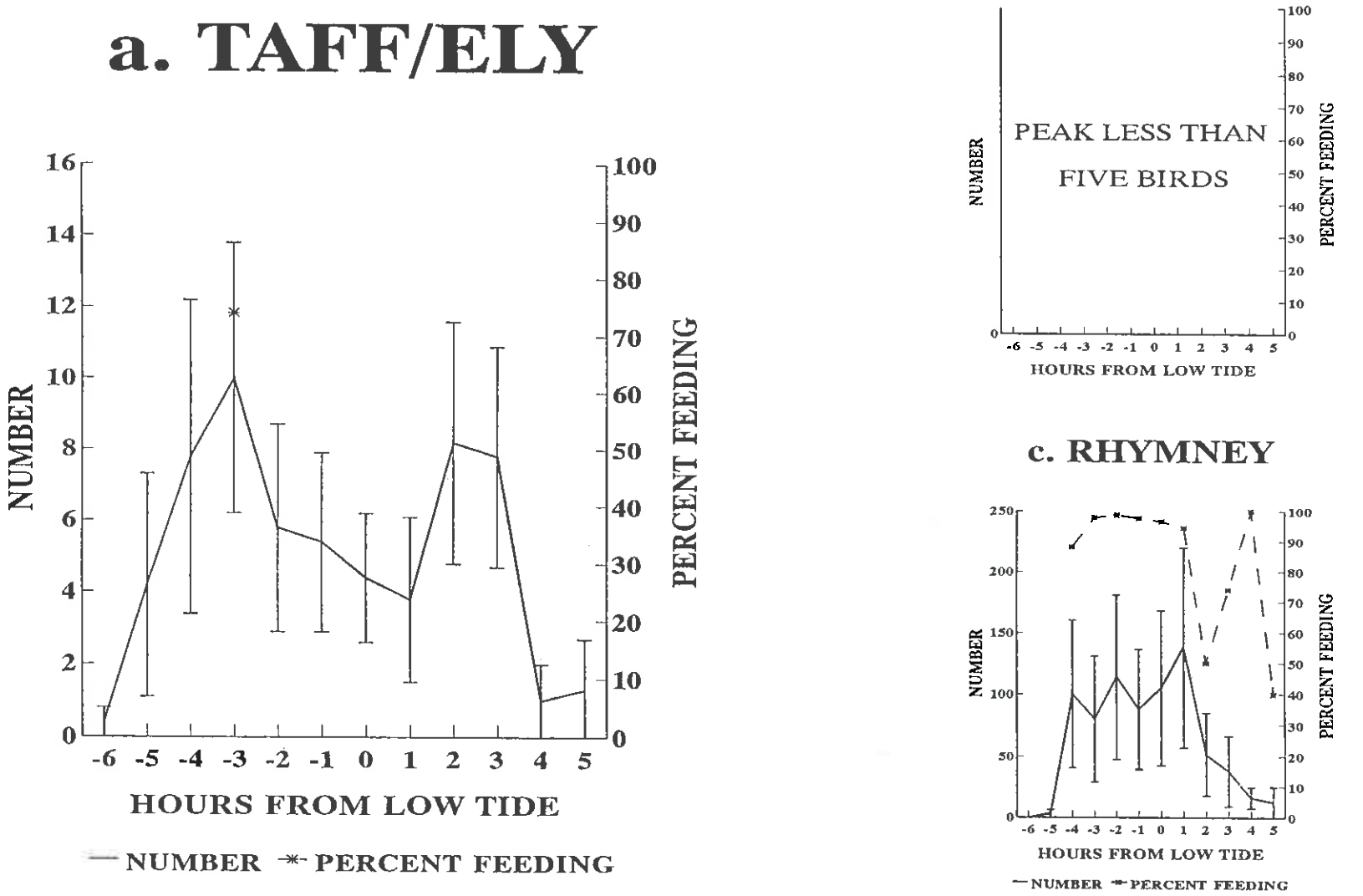


Figure 3.1.3 The total number of Shelduck present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during autumn 1995.

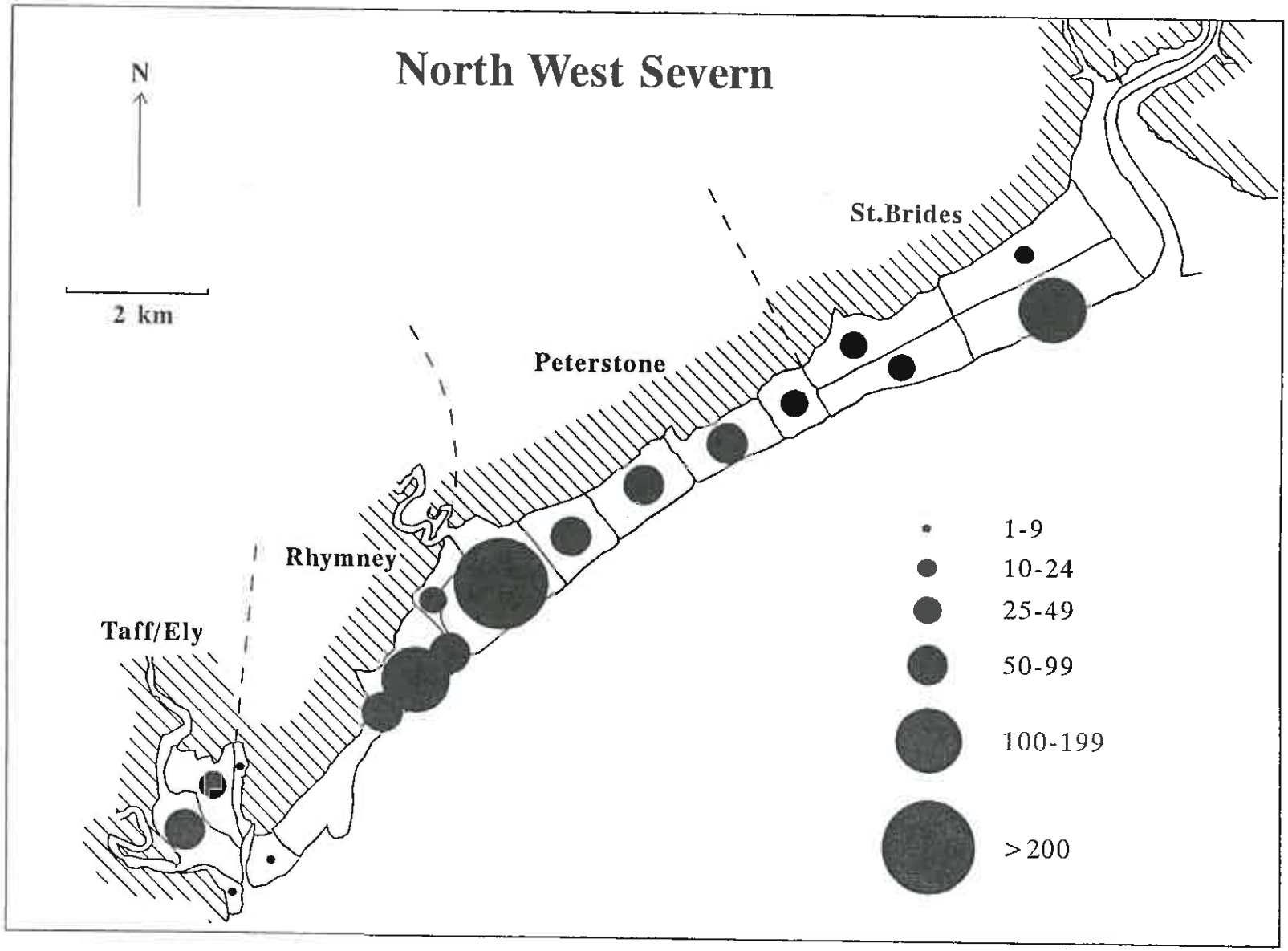


Figure 3.1.4 The low tide distribution of feeding Shelduck on the northwest Severn during winter 1995/96.

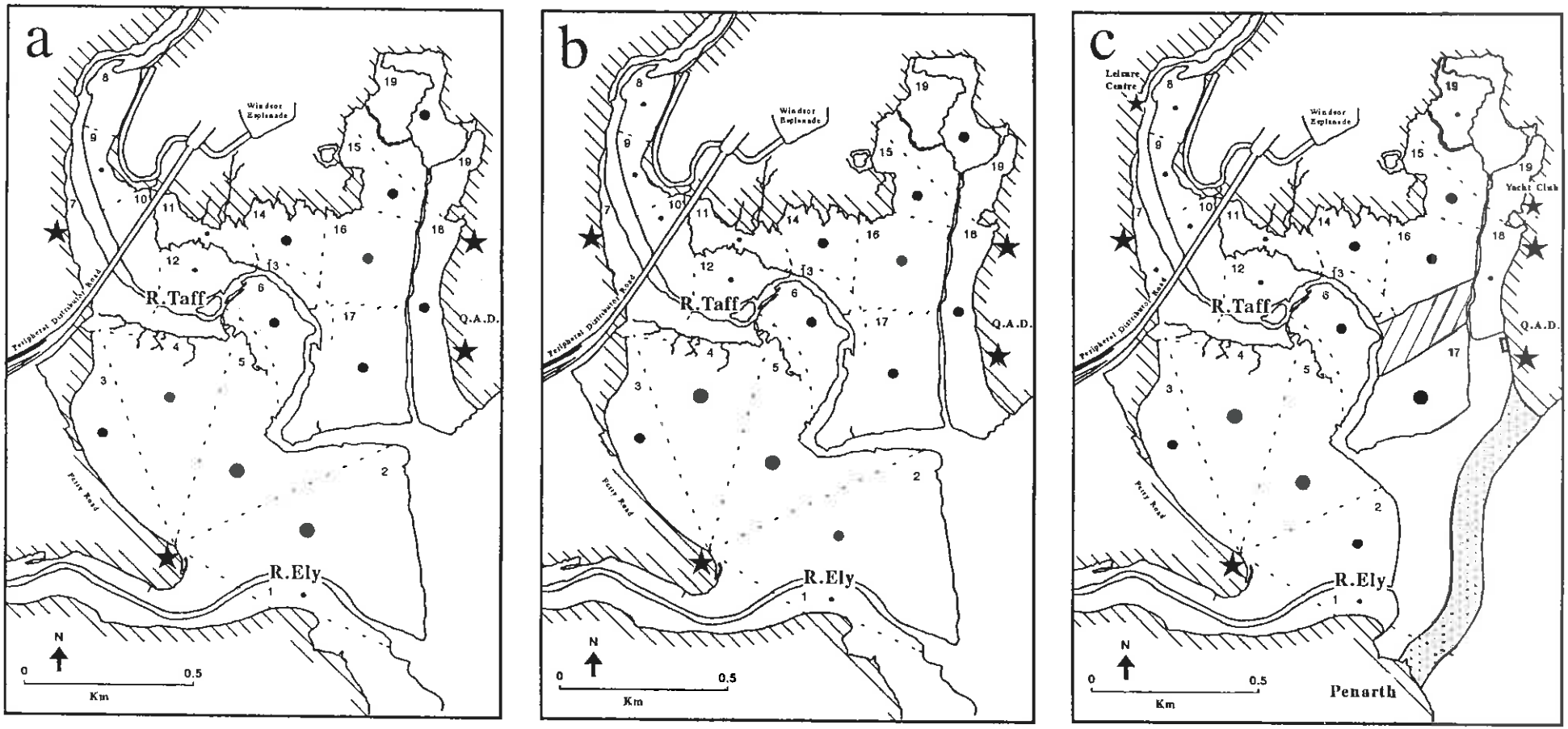


Figure 3.1.5
The distribution of feeding Shelduck on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-24	·	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

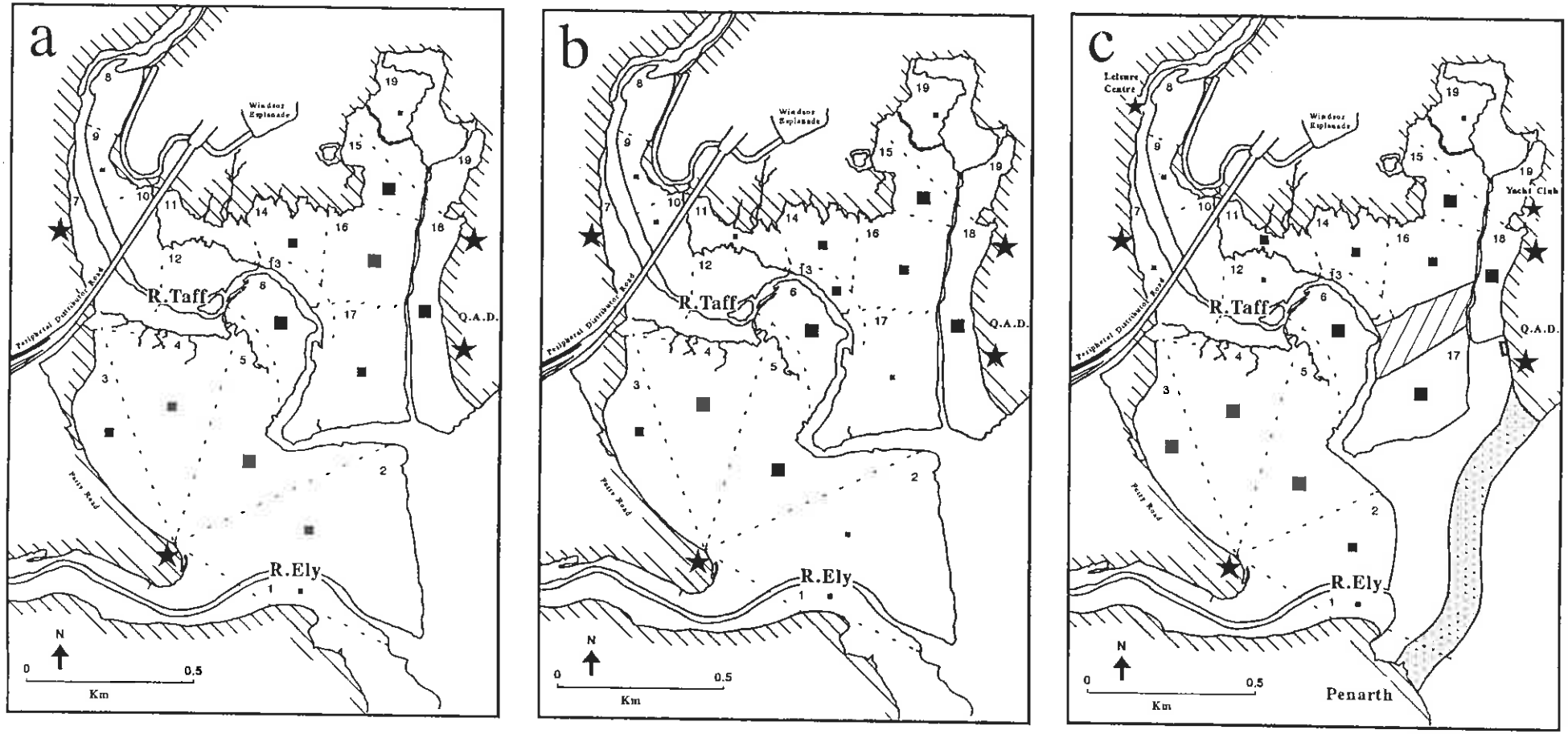


Figure 3.1.6
The distribution of feeding Shelduck on the Taff/Ely all day site during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	·	20-29	■
5-9	■	30-49	■
10-19	■	>50	■

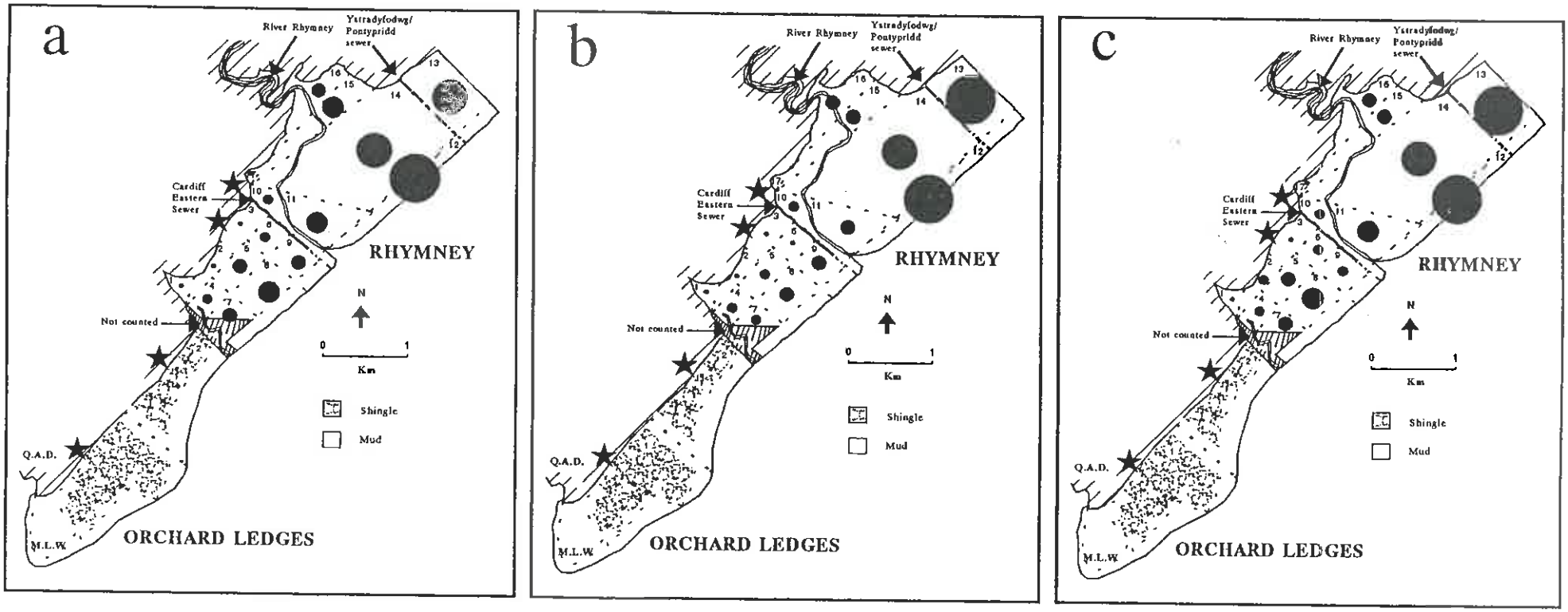


Figure 3.1.7
The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-24	•	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

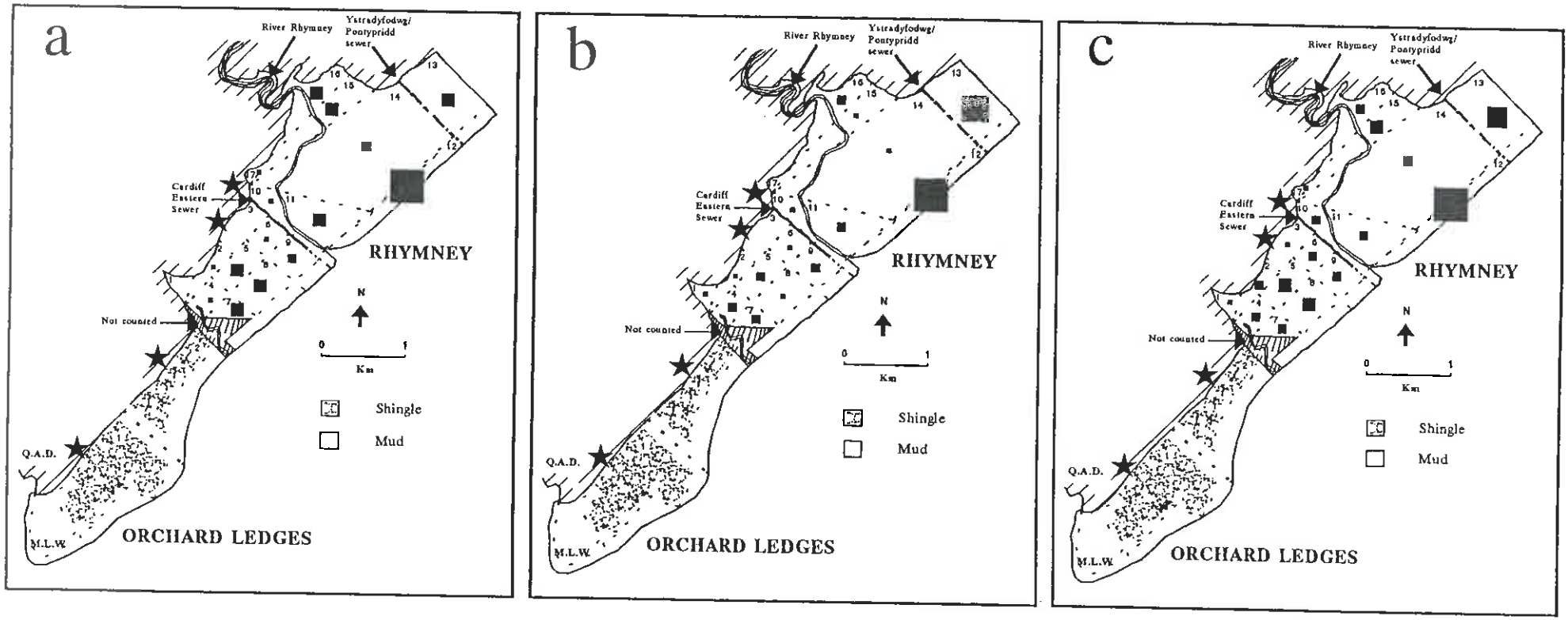


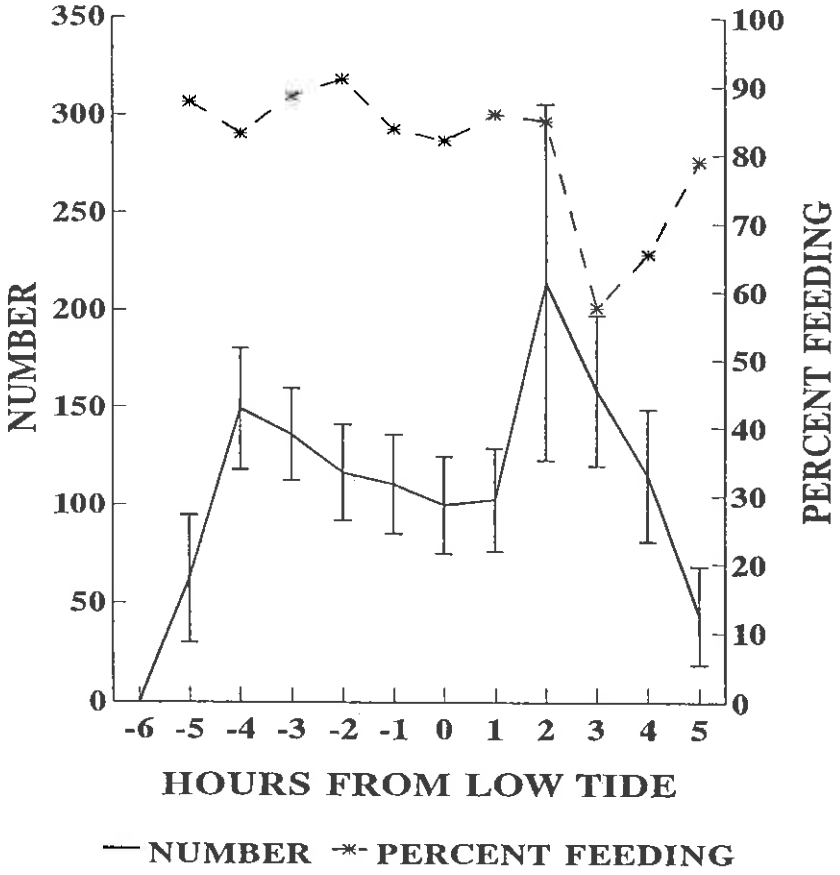
Figure 3.1.8
The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day sites during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

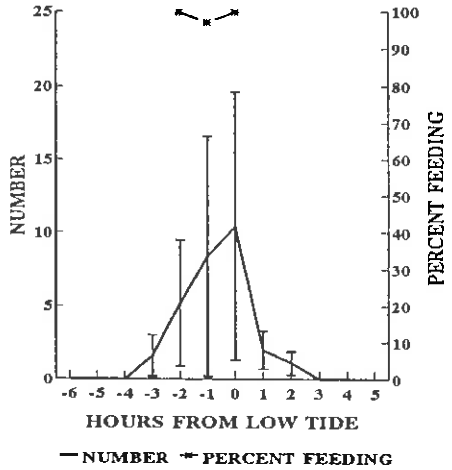
1-4	·	20-29	■
5-9	■	30-49	■
10-19	■	>50	■

SHELDUCK, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

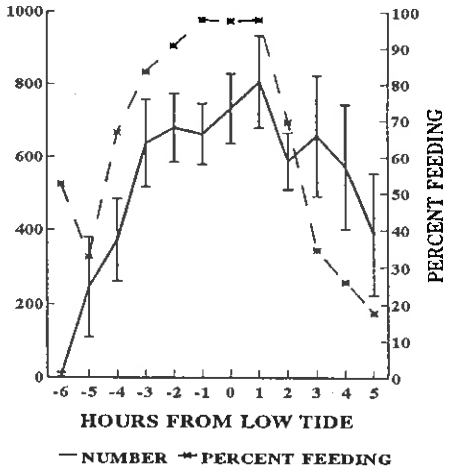


Figure 3.1.9 The total number of Shelduck present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

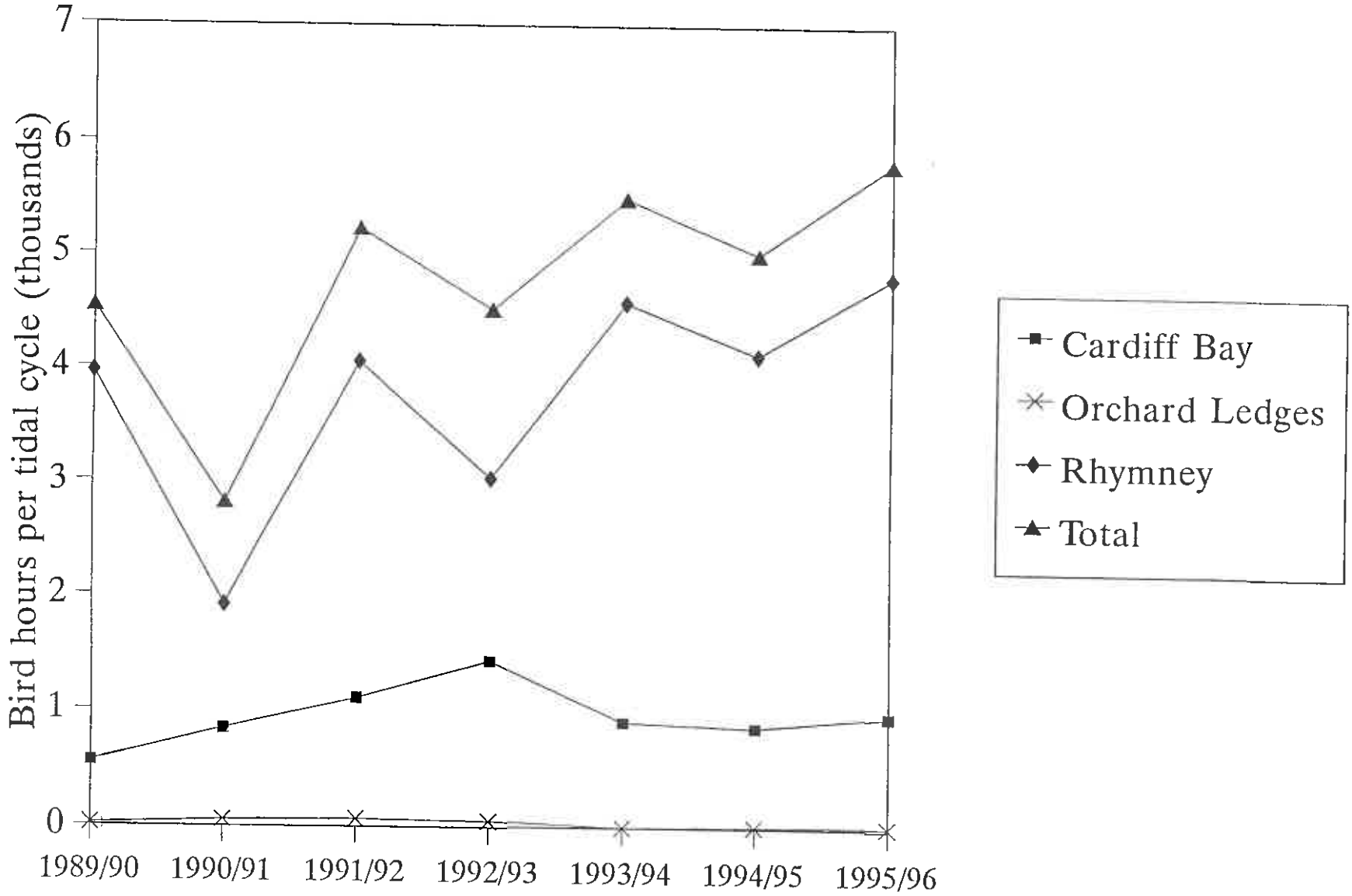


Figure 3.1.10 The all-day usage of the three study sites by Shelduck between 1989/90 and 1995/96.

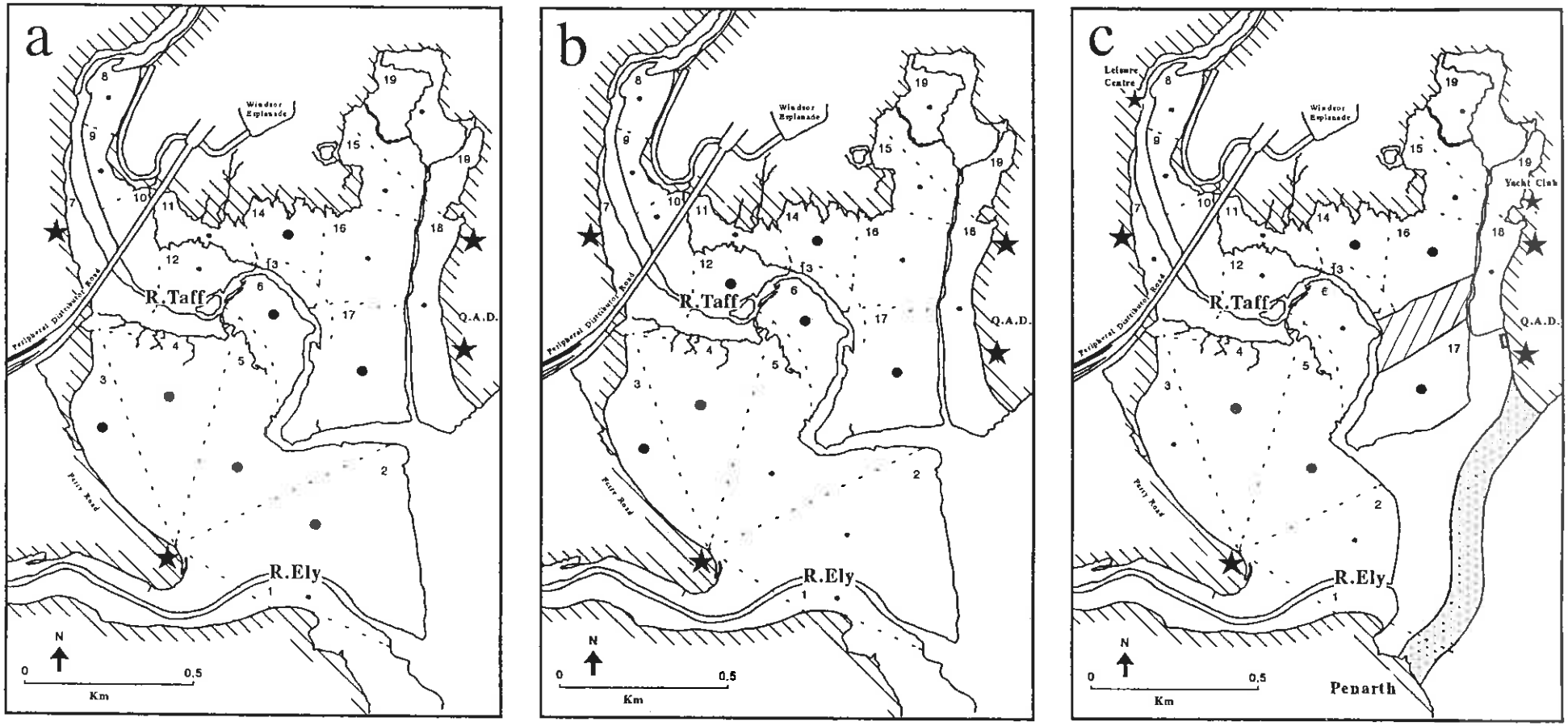


Figure 3.1.11
The distribution of feeding Shelduck on the Taff/Ely all day site during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1995; c = 1996.

Key

1-24	•	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

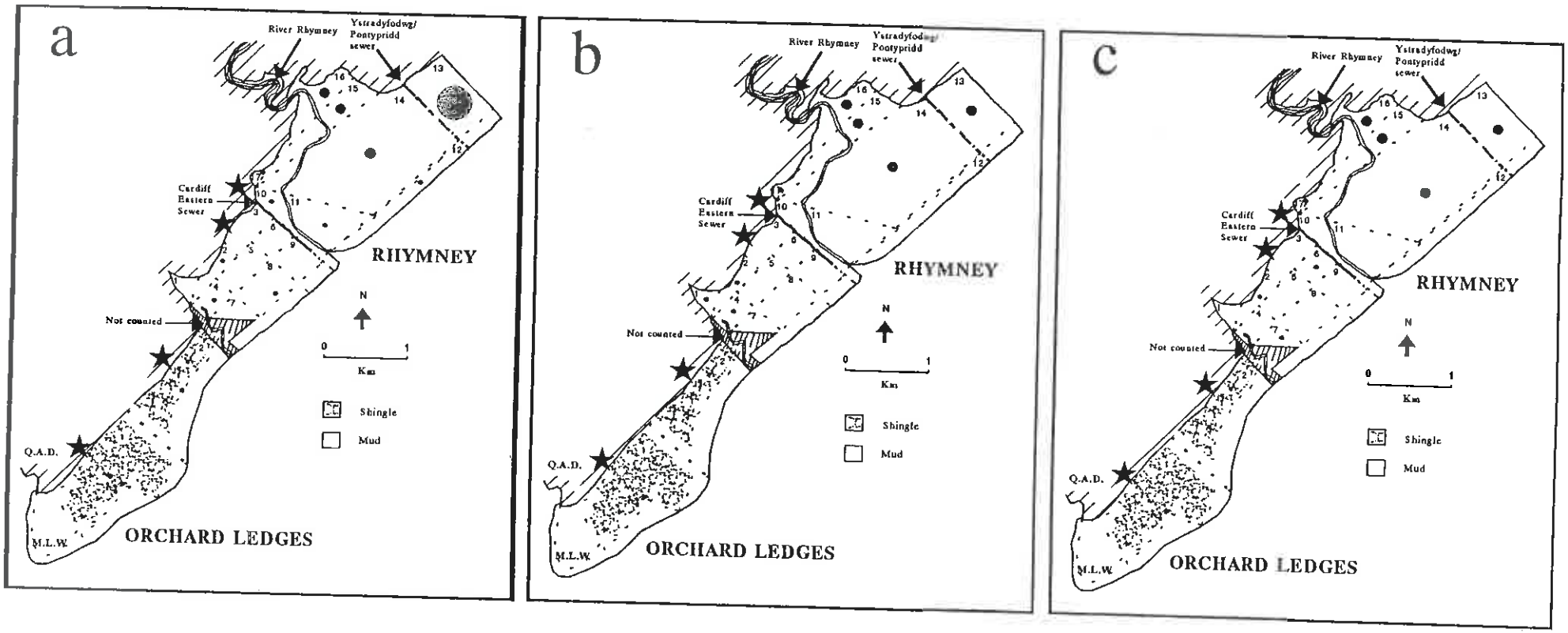


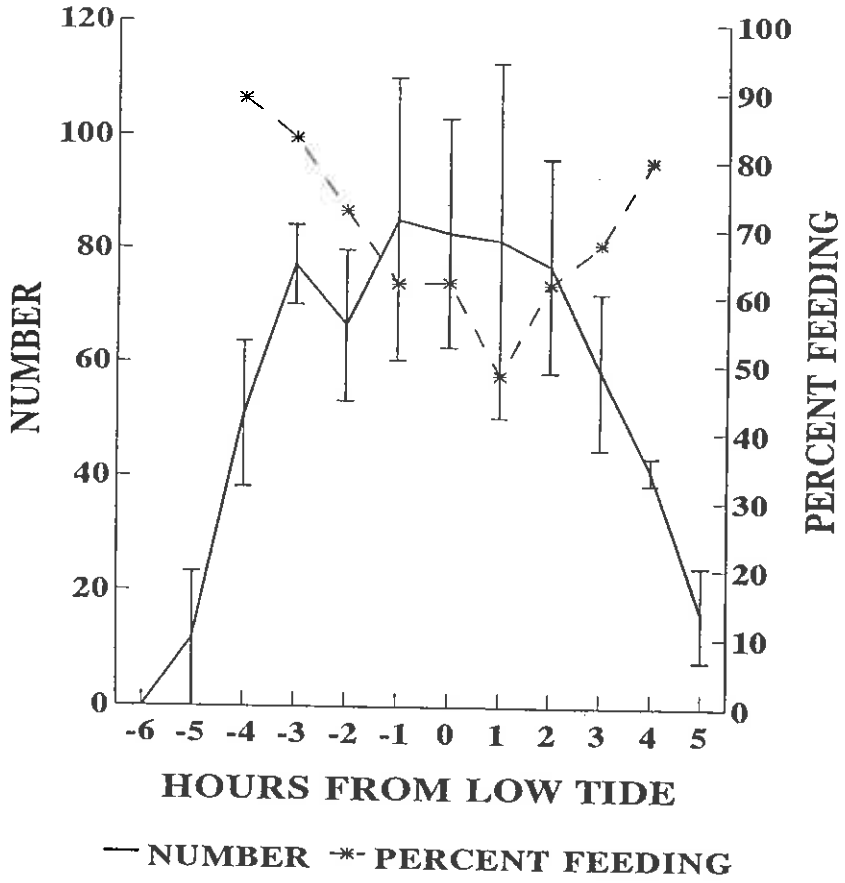
Figure 3.1.12
The distribution of feeding Shelduck on the Rhymney and Orchard Ledges all day sites during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1995; c = 1996.

Key

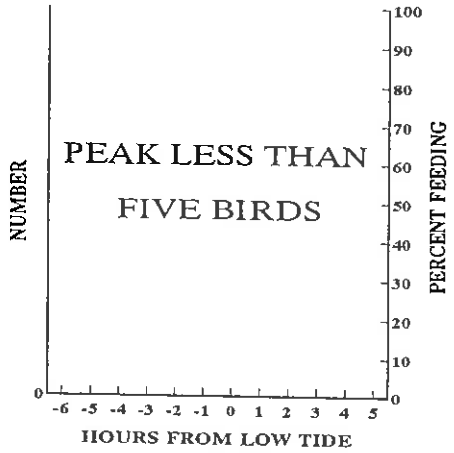
1-24	·	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

SHELDUCK, SPRING 1996

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

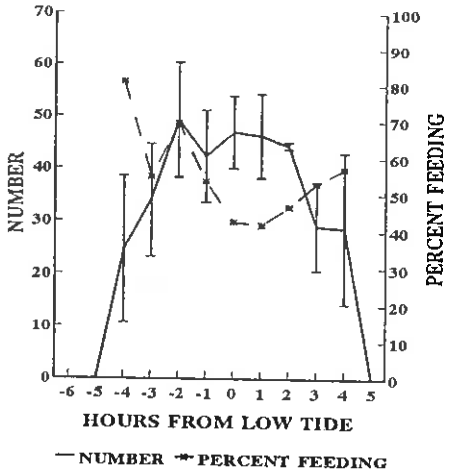


Figure 3.1.13 The total number of Shelduck present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during spring 1996.

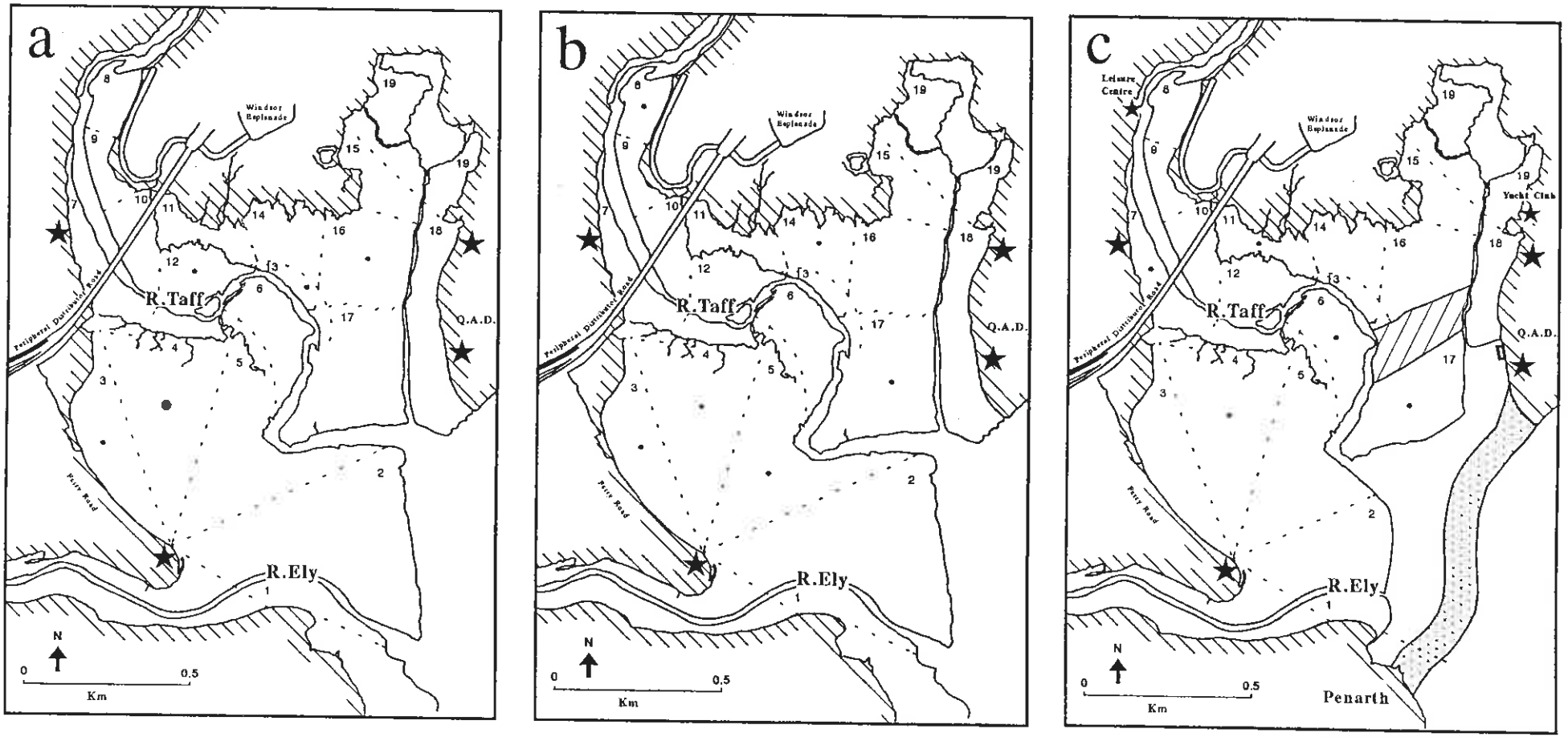


Figure 3.2.1
The distribution of feeding Dunlin on the Taff/Ely all day site during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-49	·	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

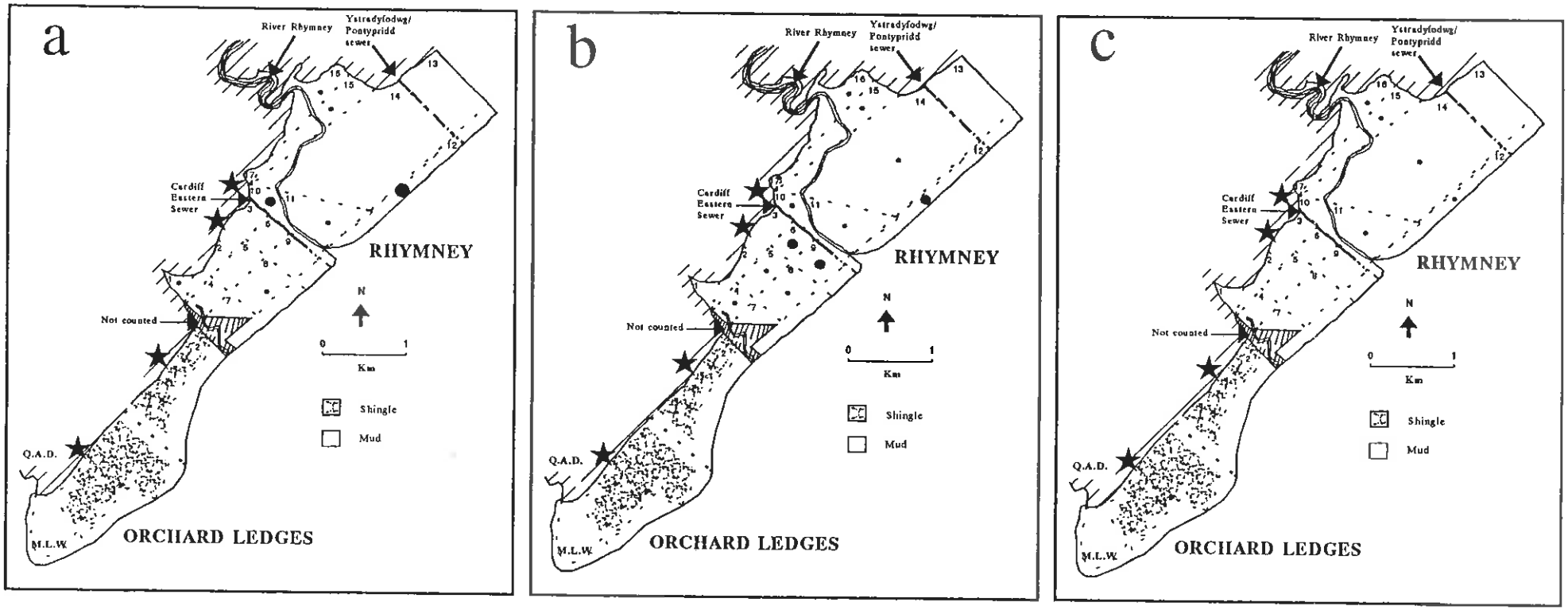


Figure 3.2.2
The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day sites during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-49	·	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

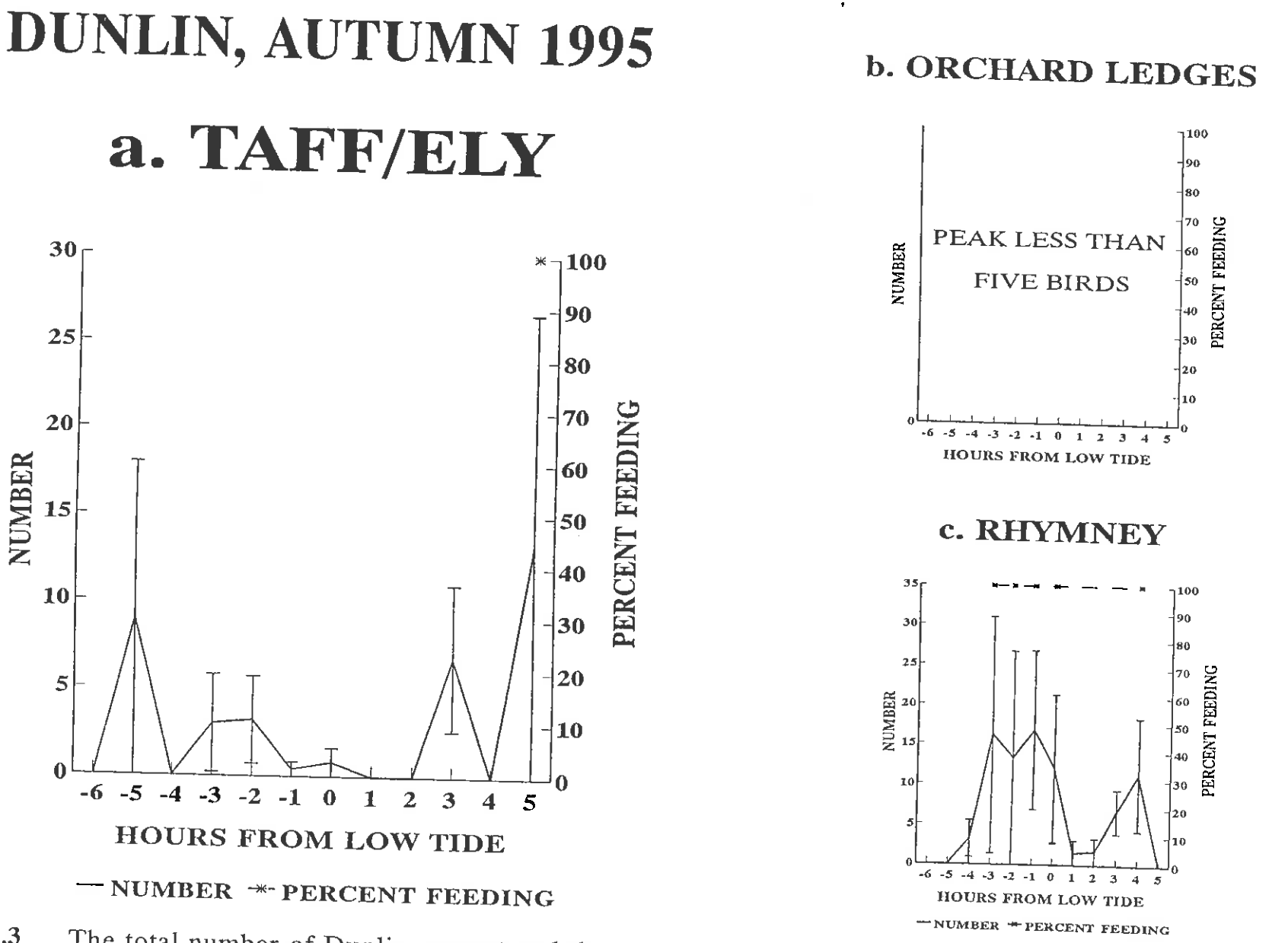


Figure 3.2.3 The total number of Dunlin present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during autumn 1995.

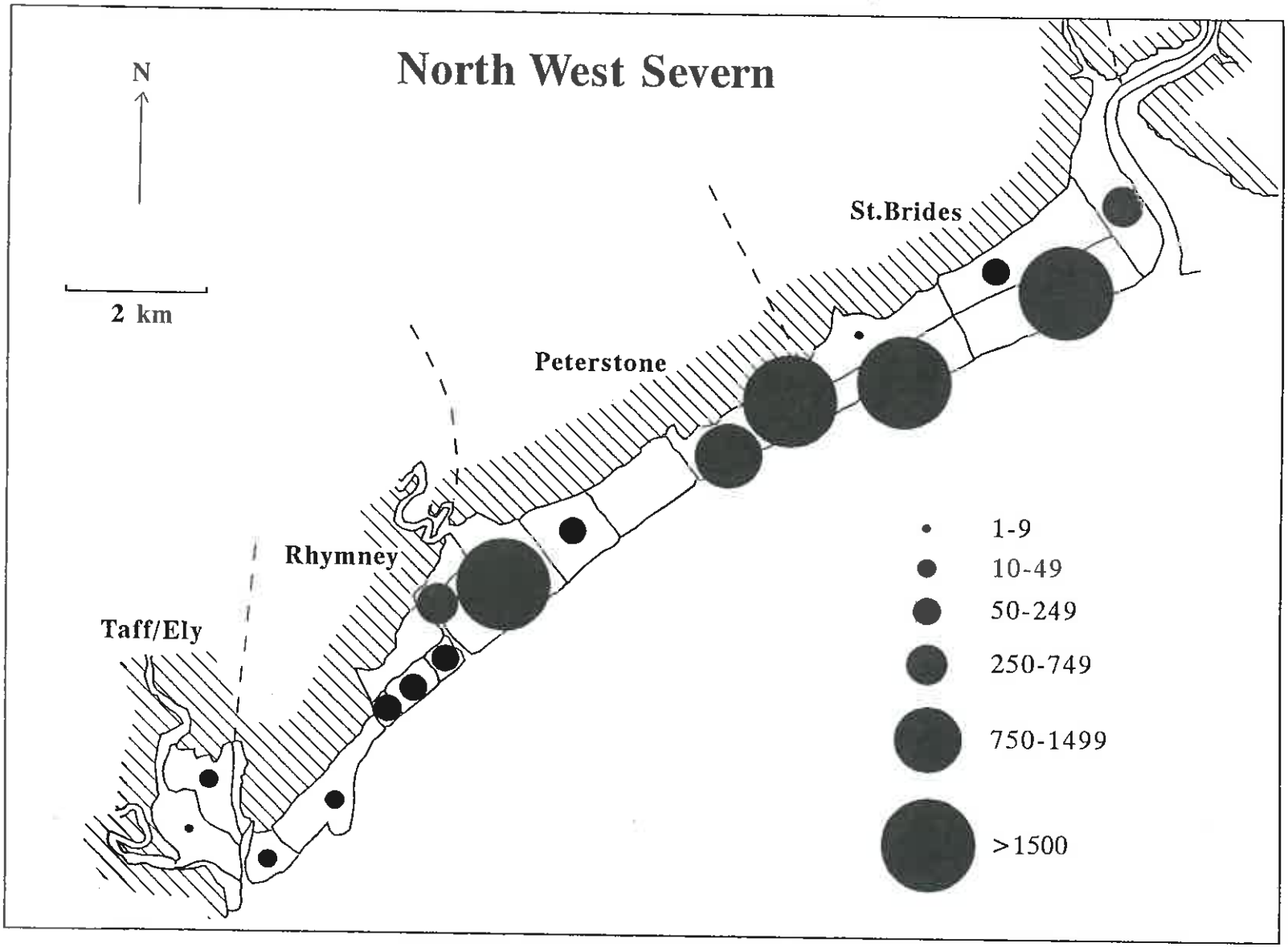


Figure 3.2.4 The low tide distribution of feeding Dunlin on the northwest Severn during winter 1995/96.

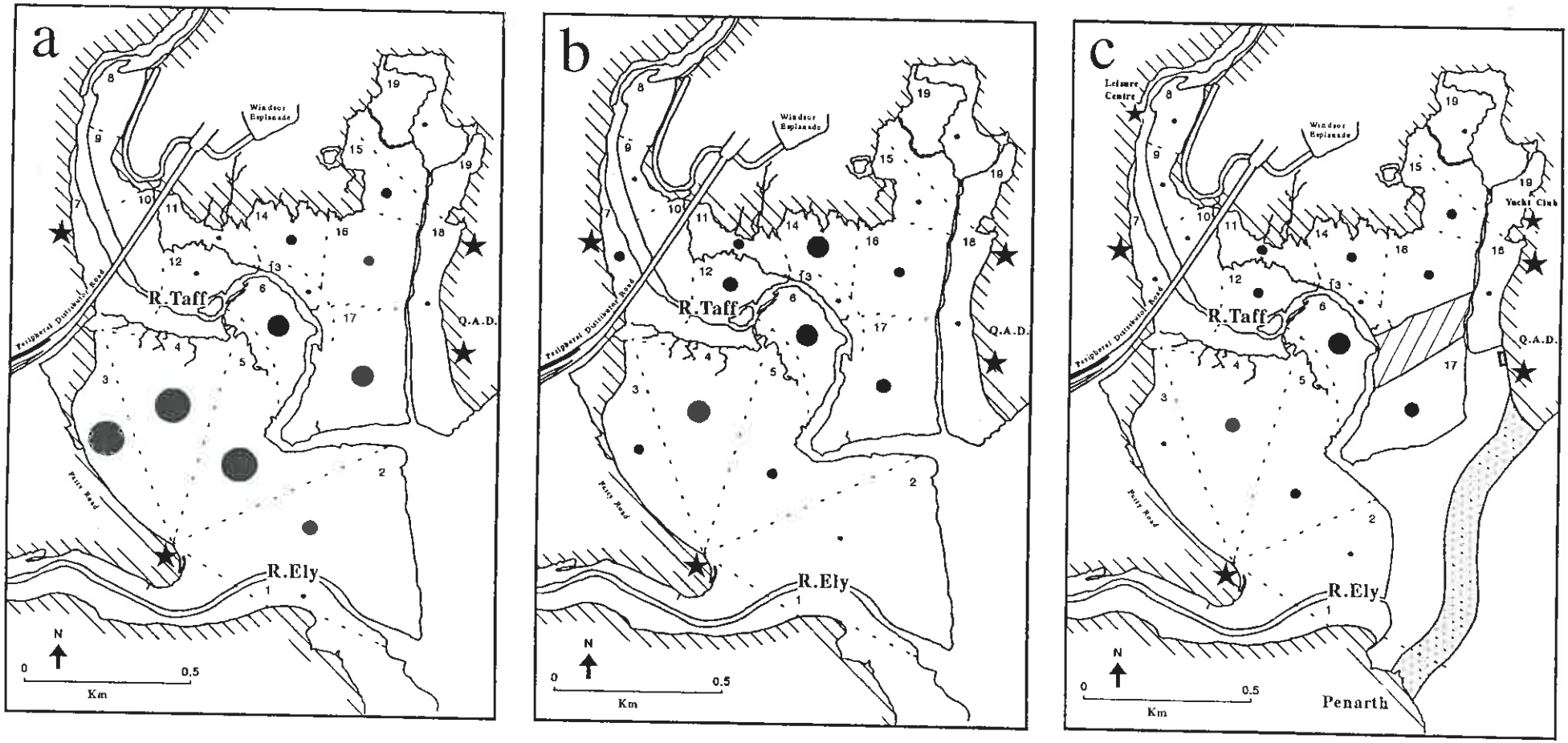


Figure 3.2.5
The distribution of feeding Dunlin on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-49	·	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

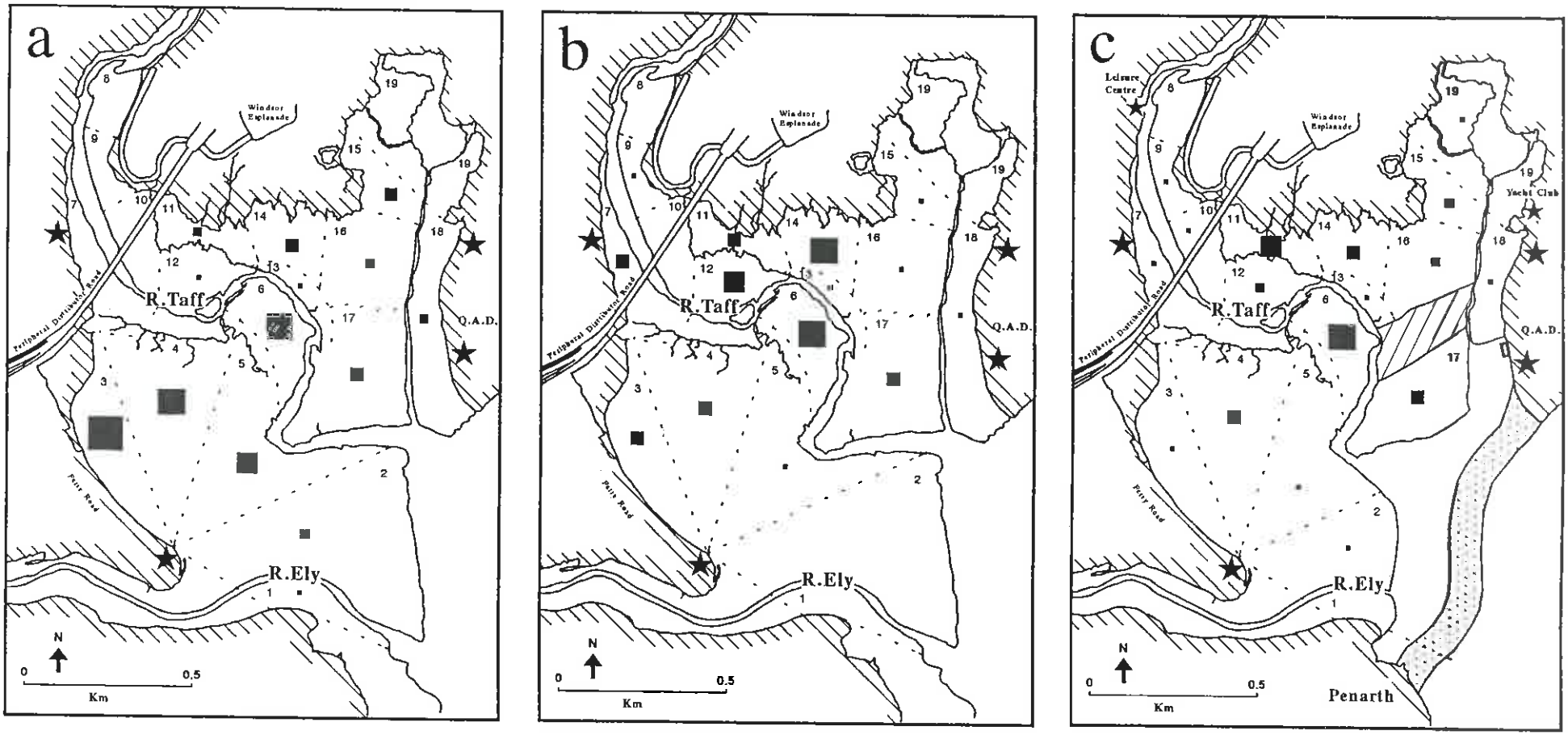


Figure 3.2.6
The distribution of feeding Dunlin on the Taff/Ely all day site during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-9	▪	50-99	■
10-24	▪	100-199	■
25-49	■	>200	■

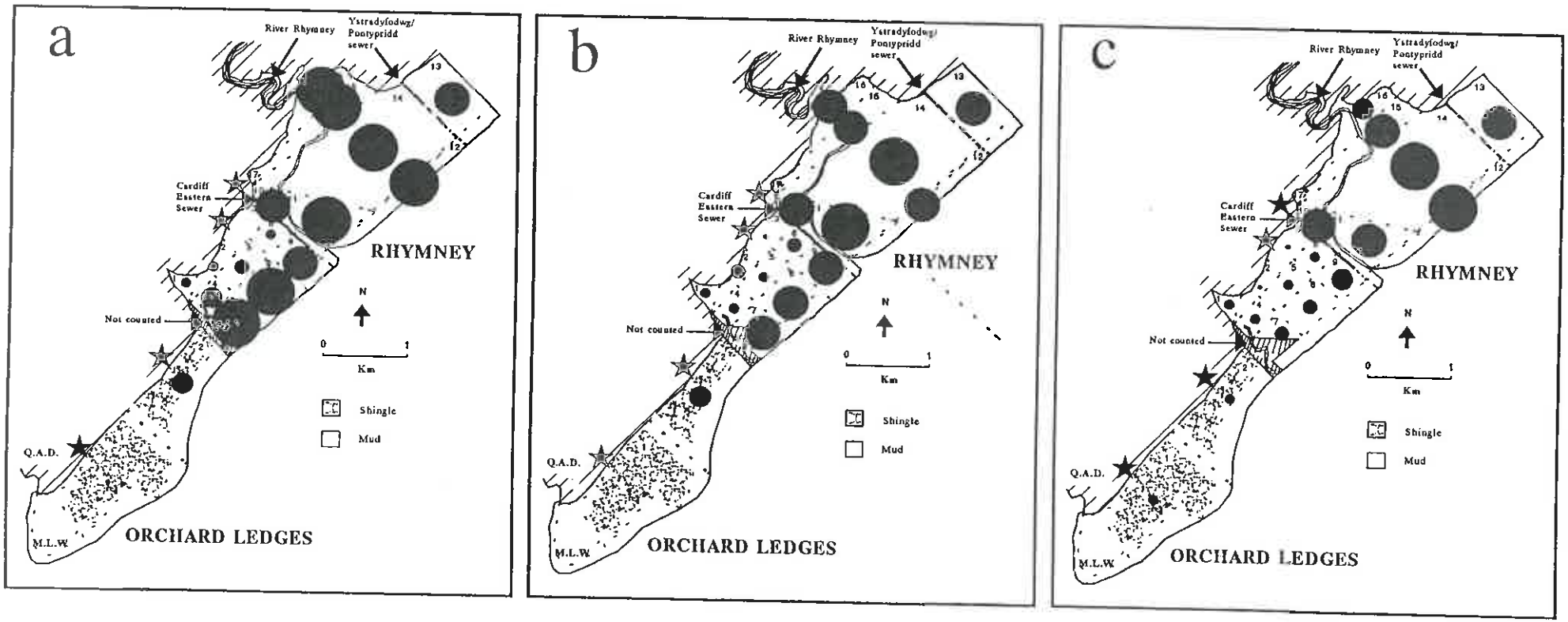


Figure 3.2.7
The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-49	·	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

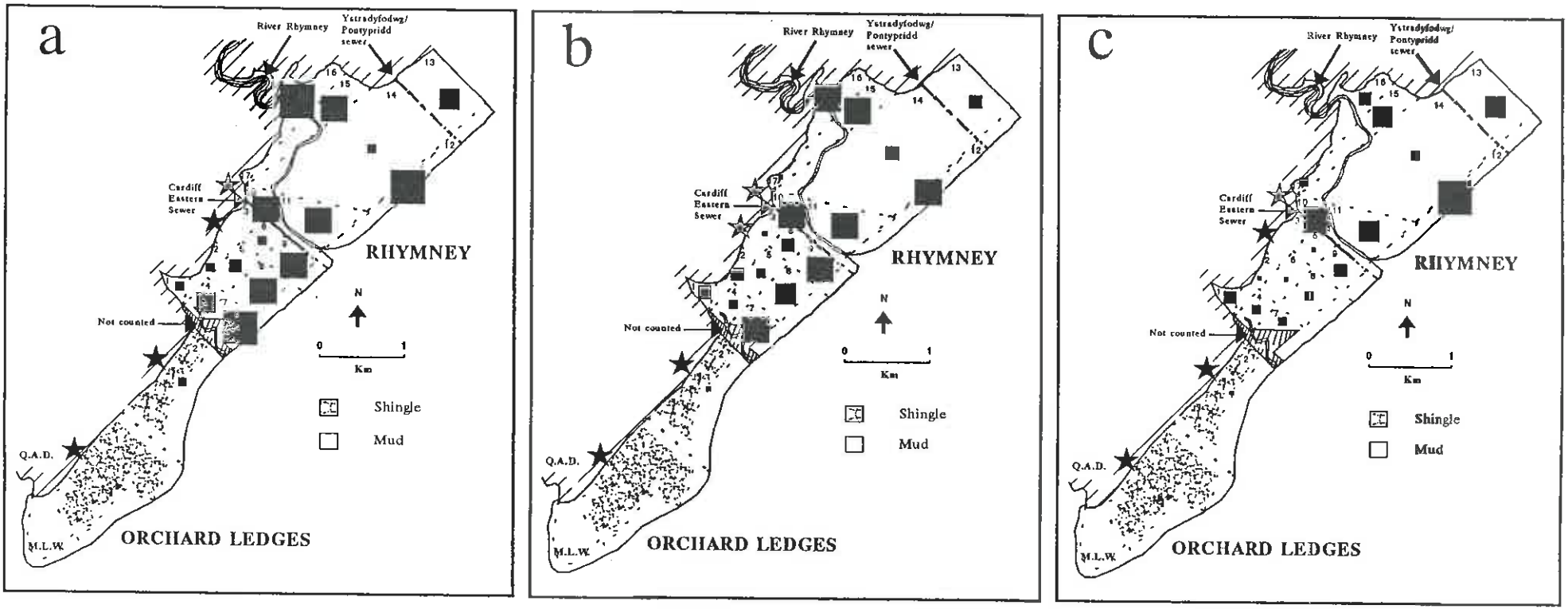


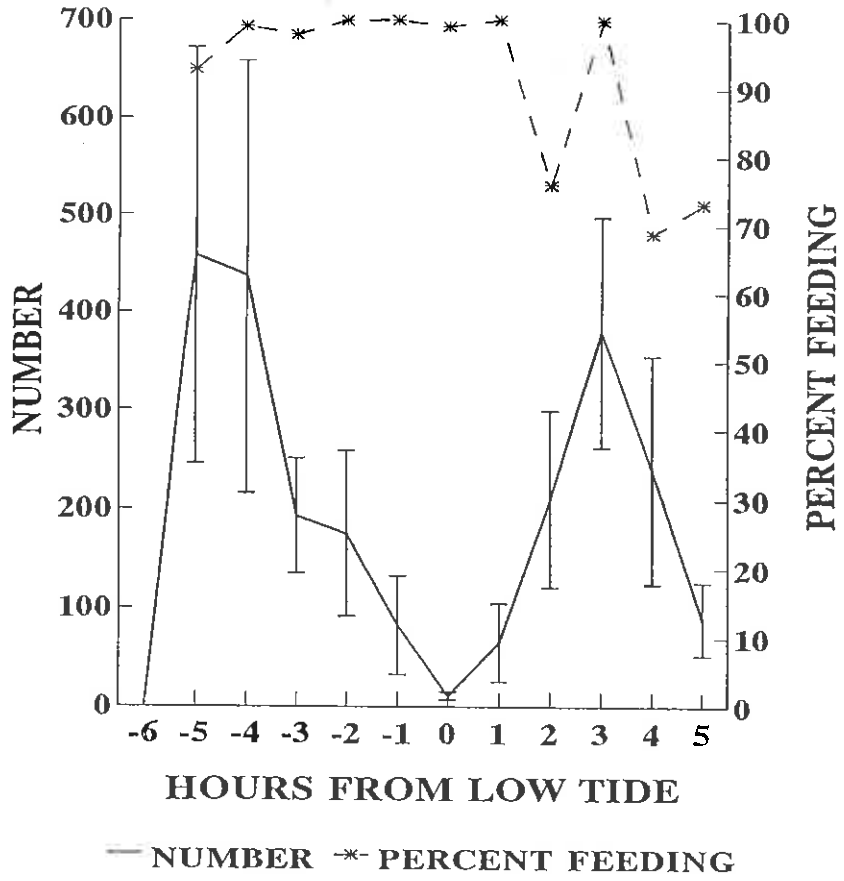
Figure 3.2.8
The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day sites during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

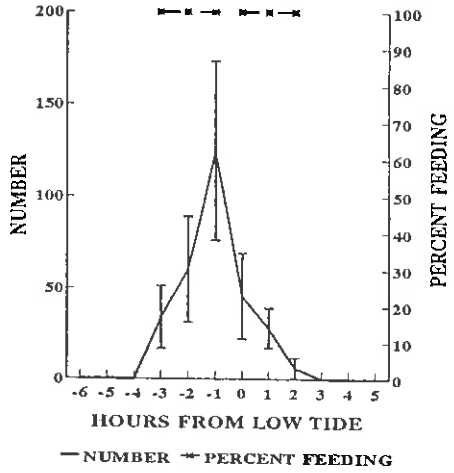
1-9	▪	50-99	■
10-24	▪	100-199	■
25-49	■	>200	■

DUNLIN, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

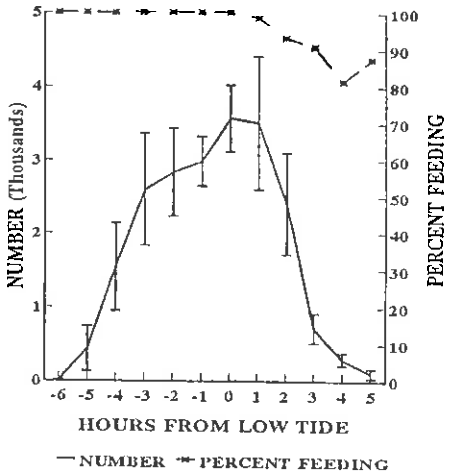


Figure 3.2.9 The total number of Dunlin present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

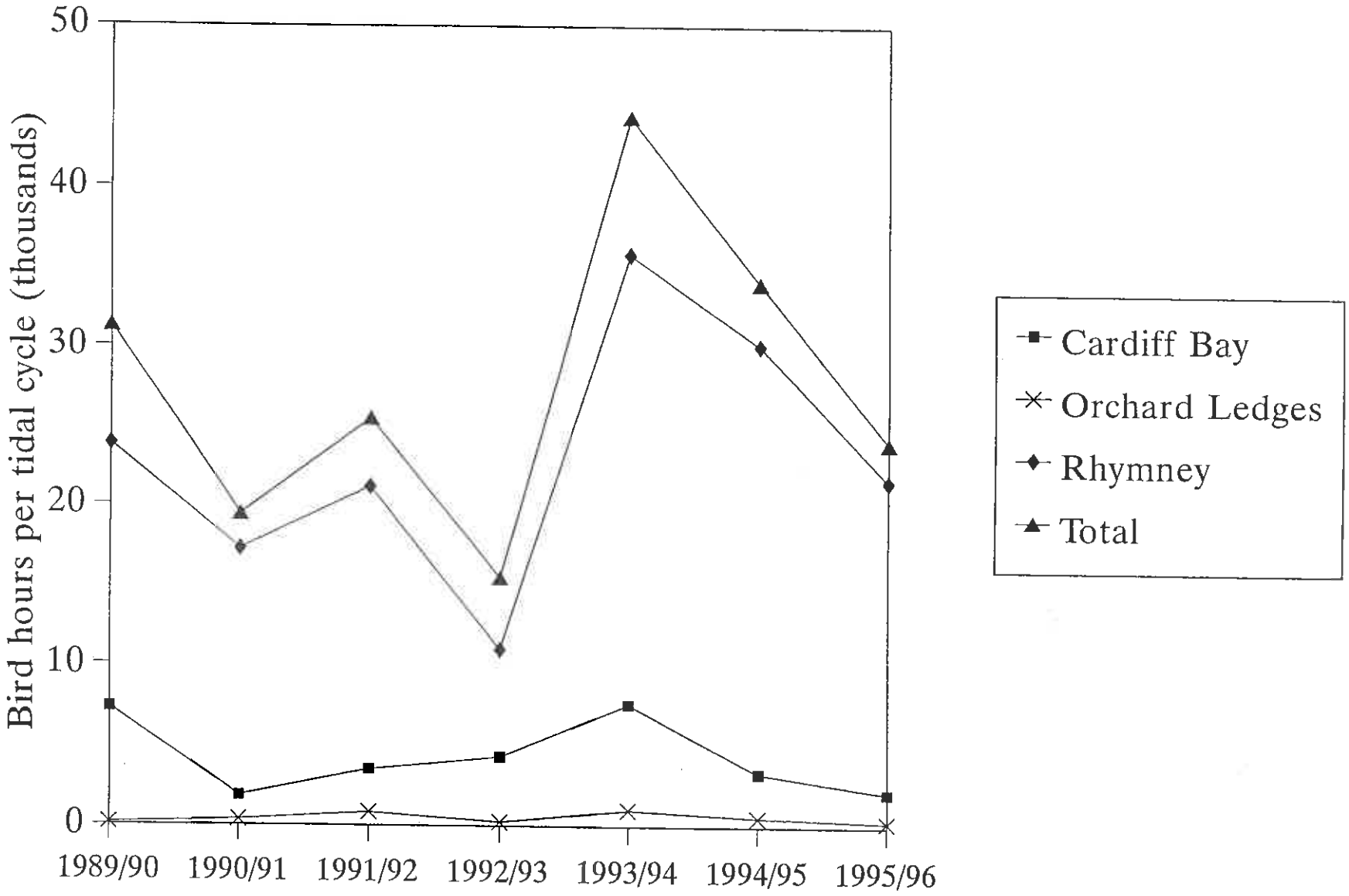


Figure 3.2.10 The all-day usage of the three study sites by Dunlin between 1989/90 and 1995/96.

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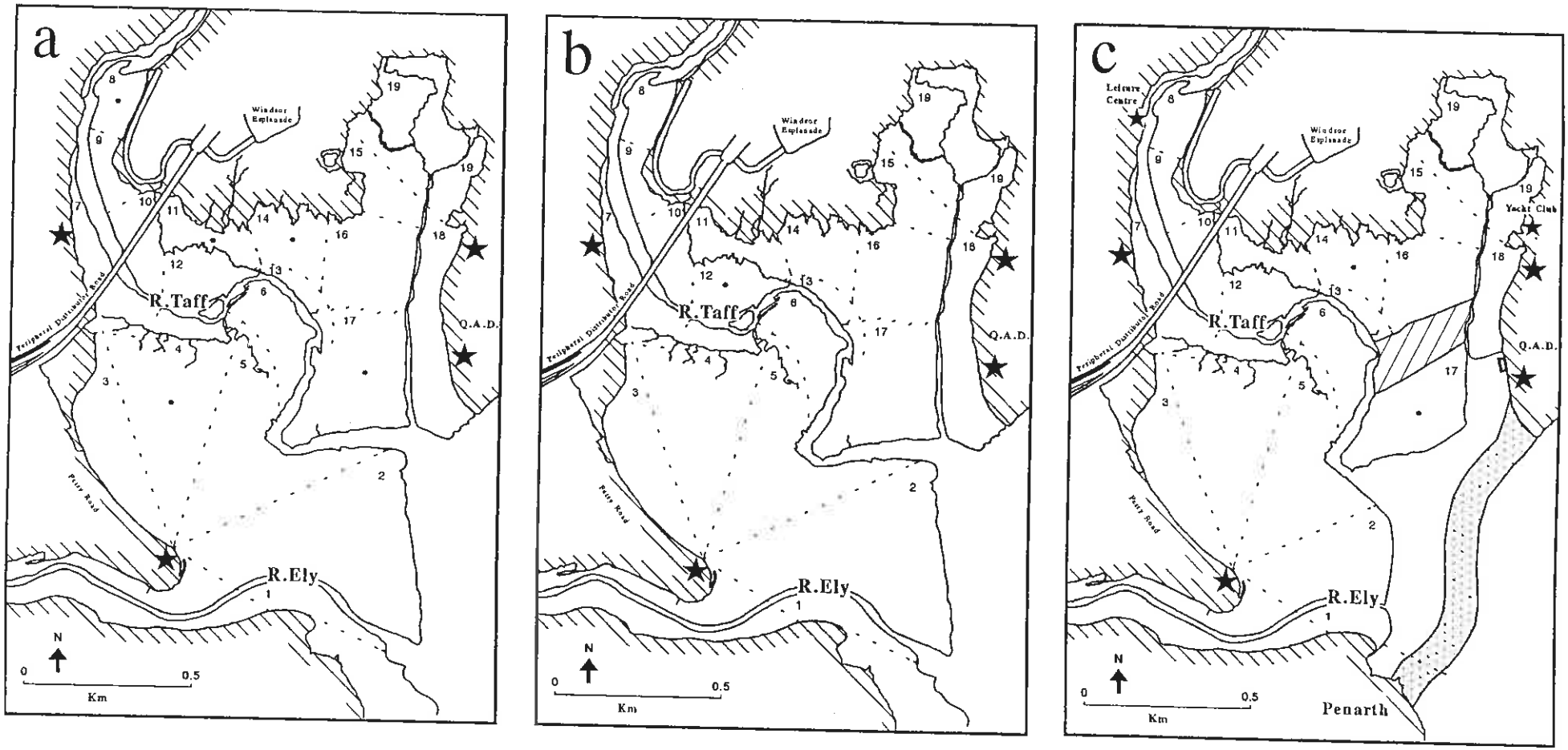


Figure 3.2.11
The distribution of feeding Dunlin on the Taff/Ely all day site during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1995; c = 1996.

Key

1-49	•	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

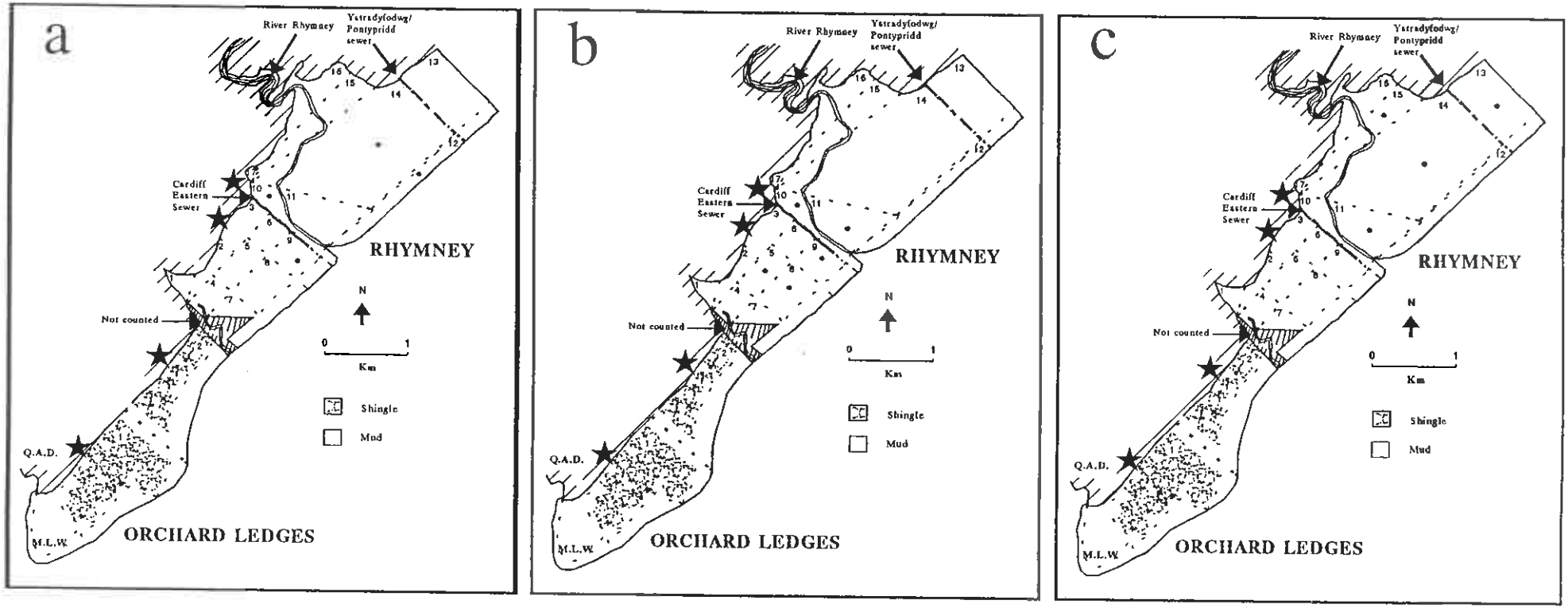


Figure 3.2.12
The distribution of feeding Dunlin on the Rhymney and Orchard Ledges all day sites during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1995; c = 1996.

Key

1-49	•	500-999	●
50-249	•	1000-2999	●
250-499	●	>3000	●

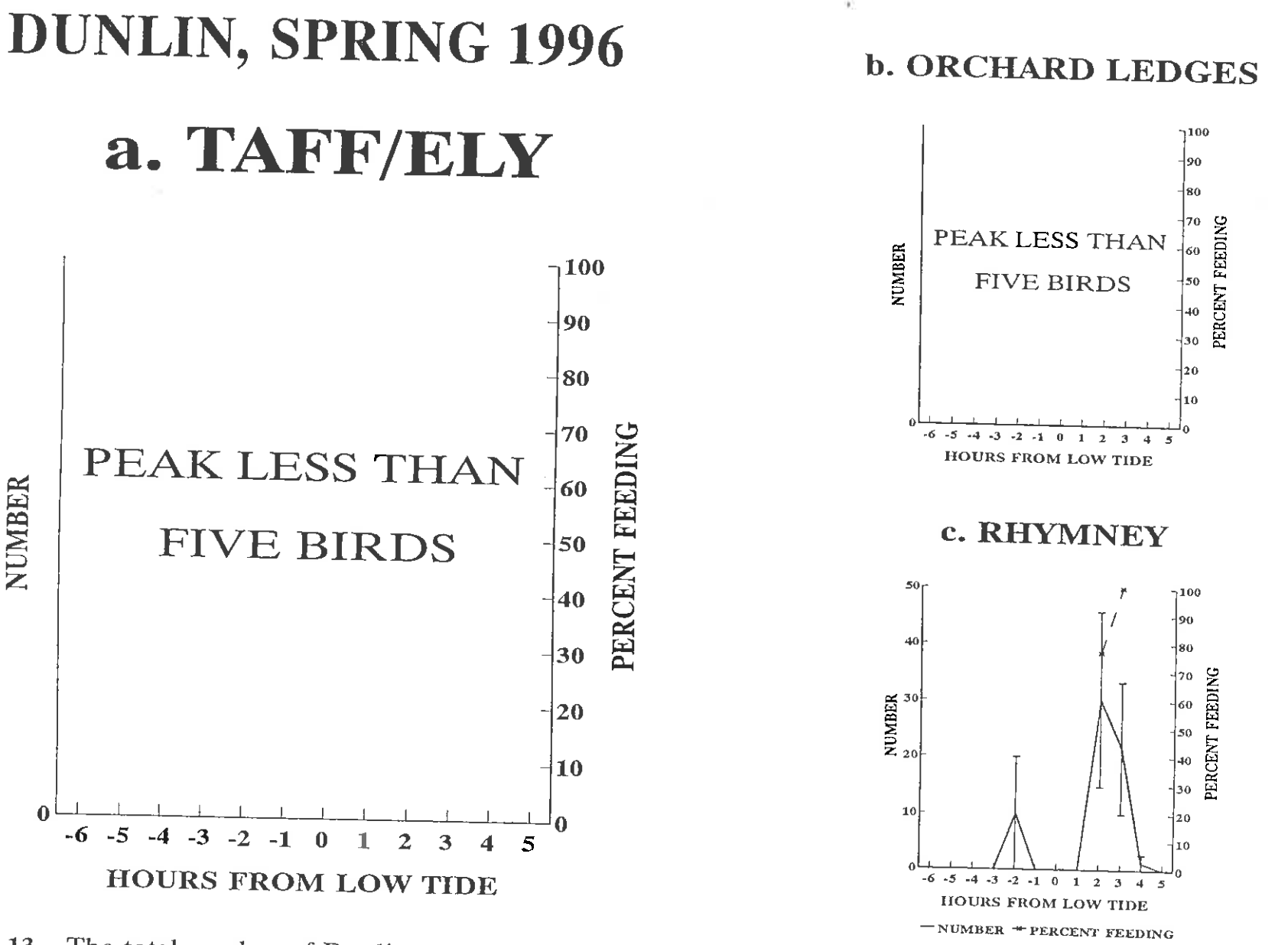


Figure 3.2.13 The total number of Dunlin present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during spring 1996.

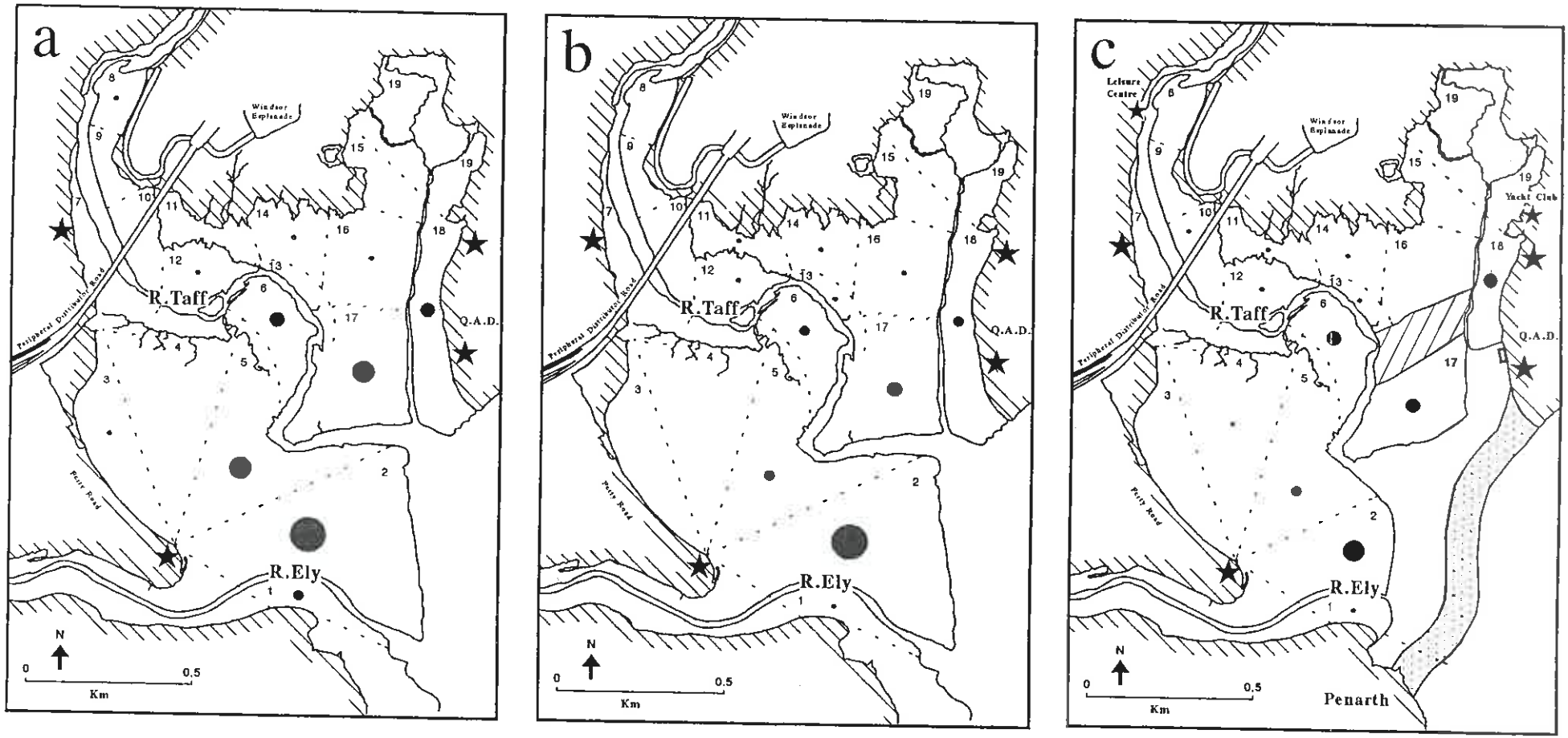


Figure 3.3.1
The distribution of feeding Curlew on the Taff/Ely all day site during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

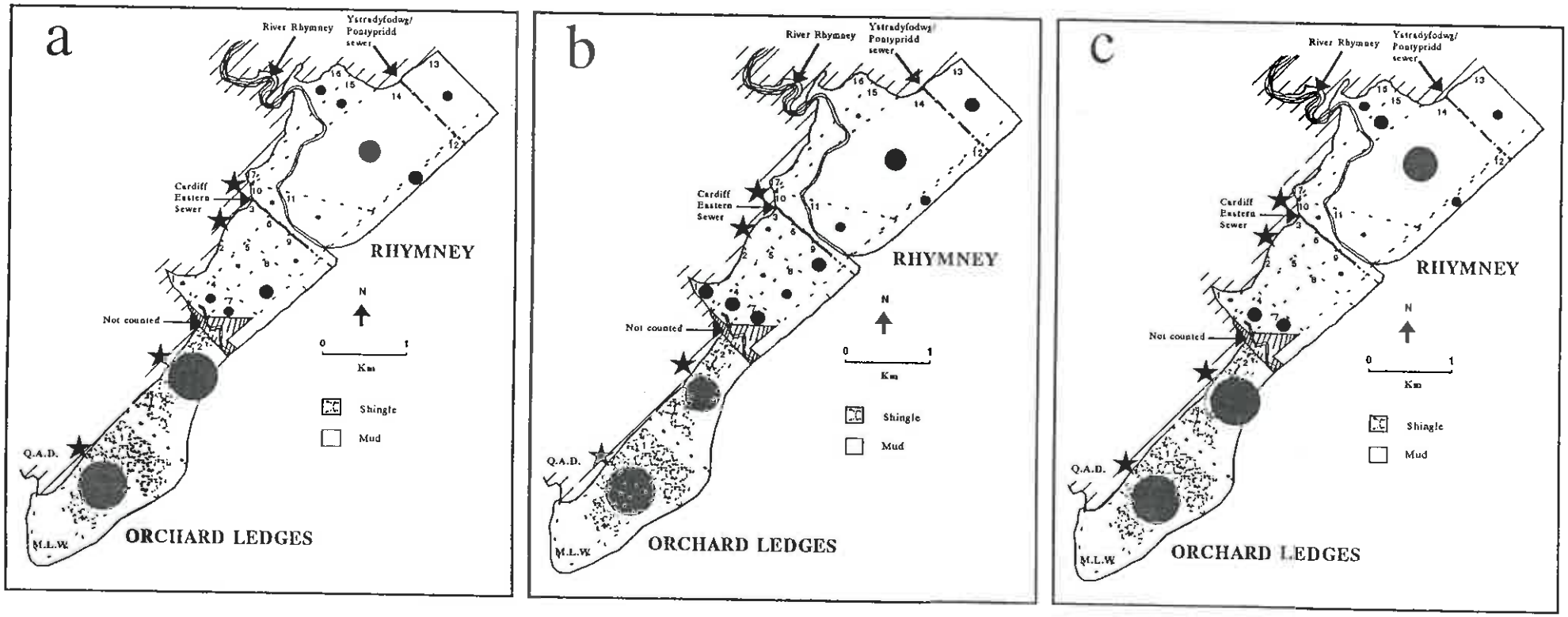


Figure 3.3.2
The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day sites during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

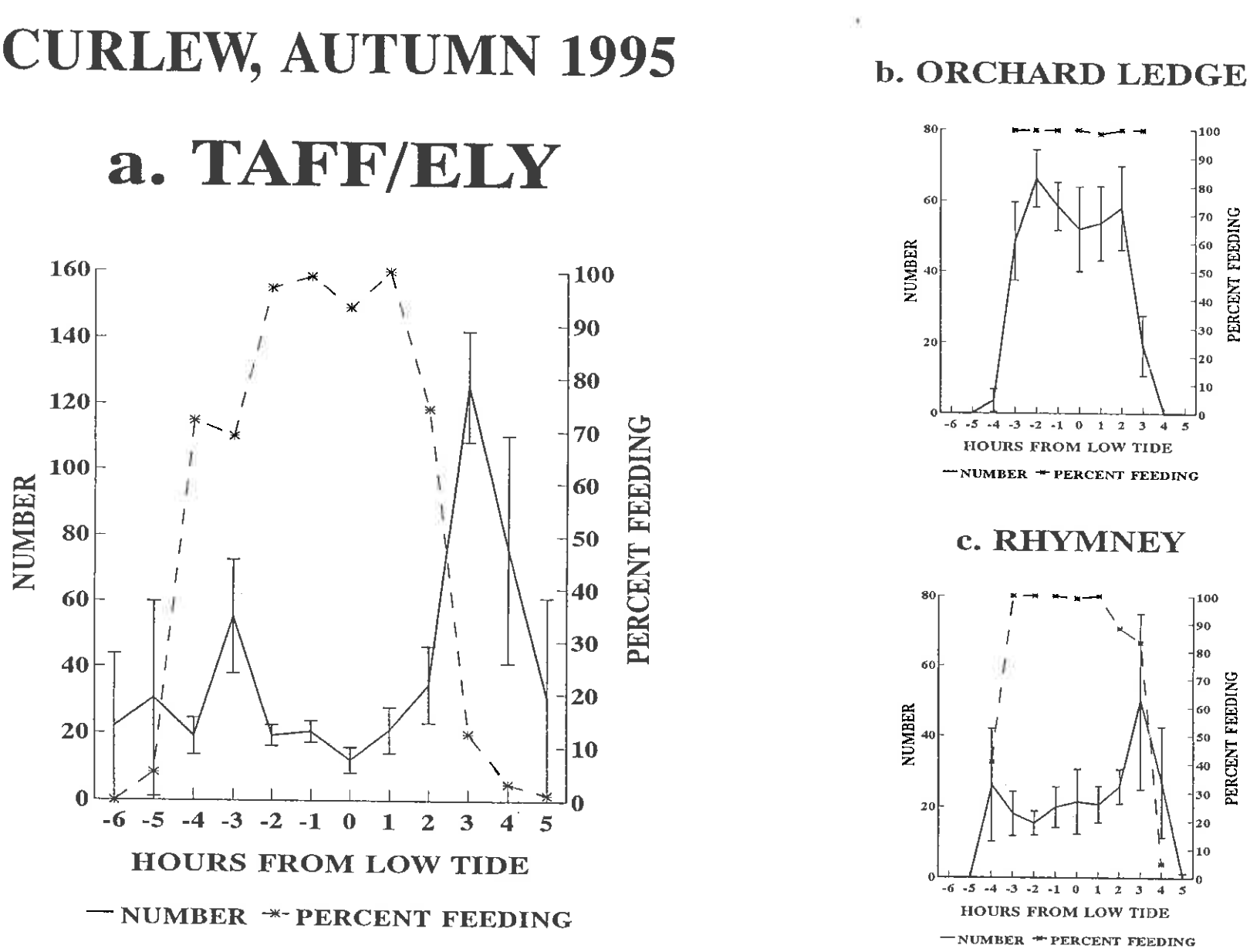


Figure 3.3.3 The total number of Curlew present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during autumn 1995.

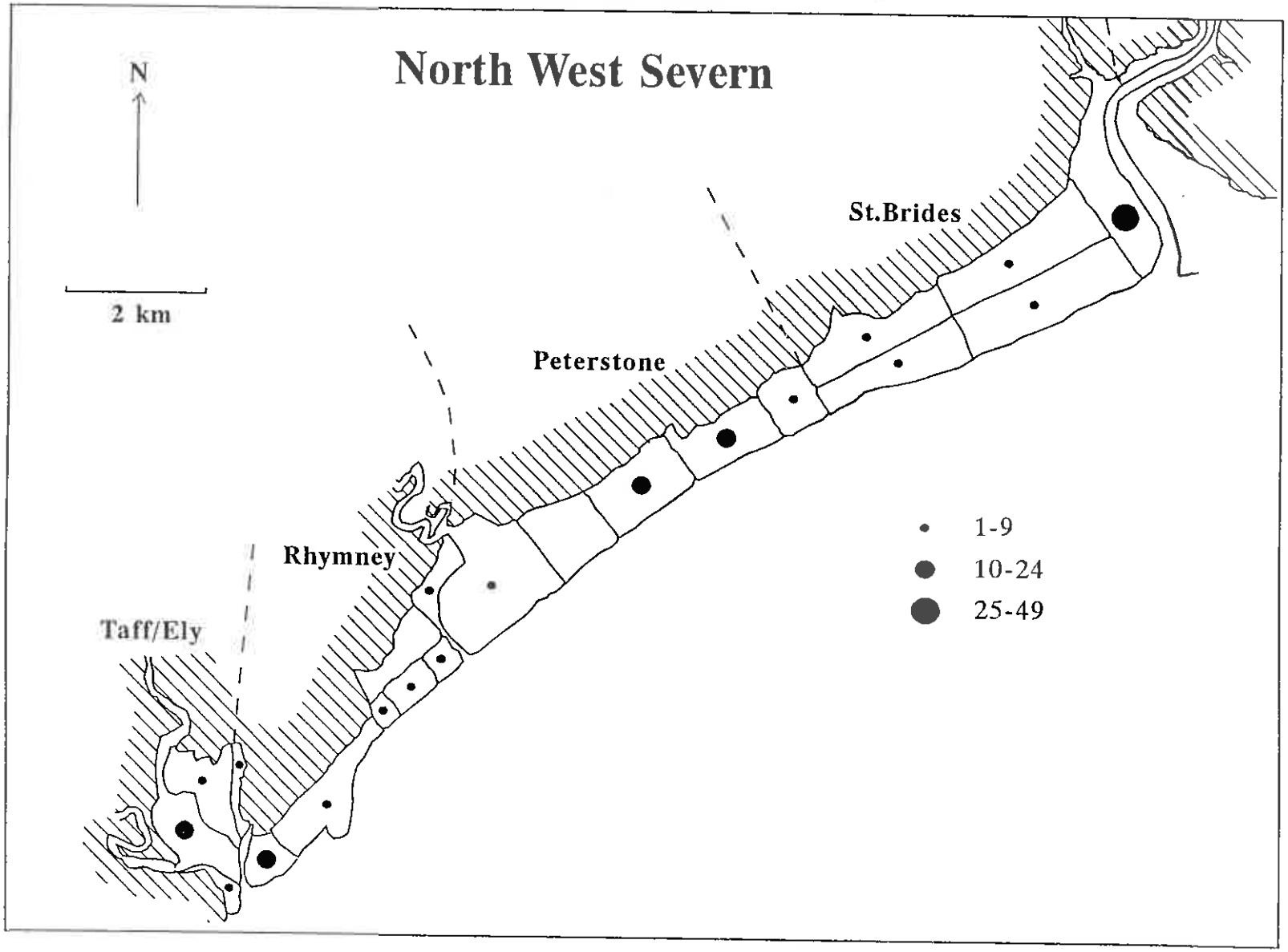


Figure 3.3.4 The low tide distribution of feeding Curlew on the northwest Severn during winter 1995/96.

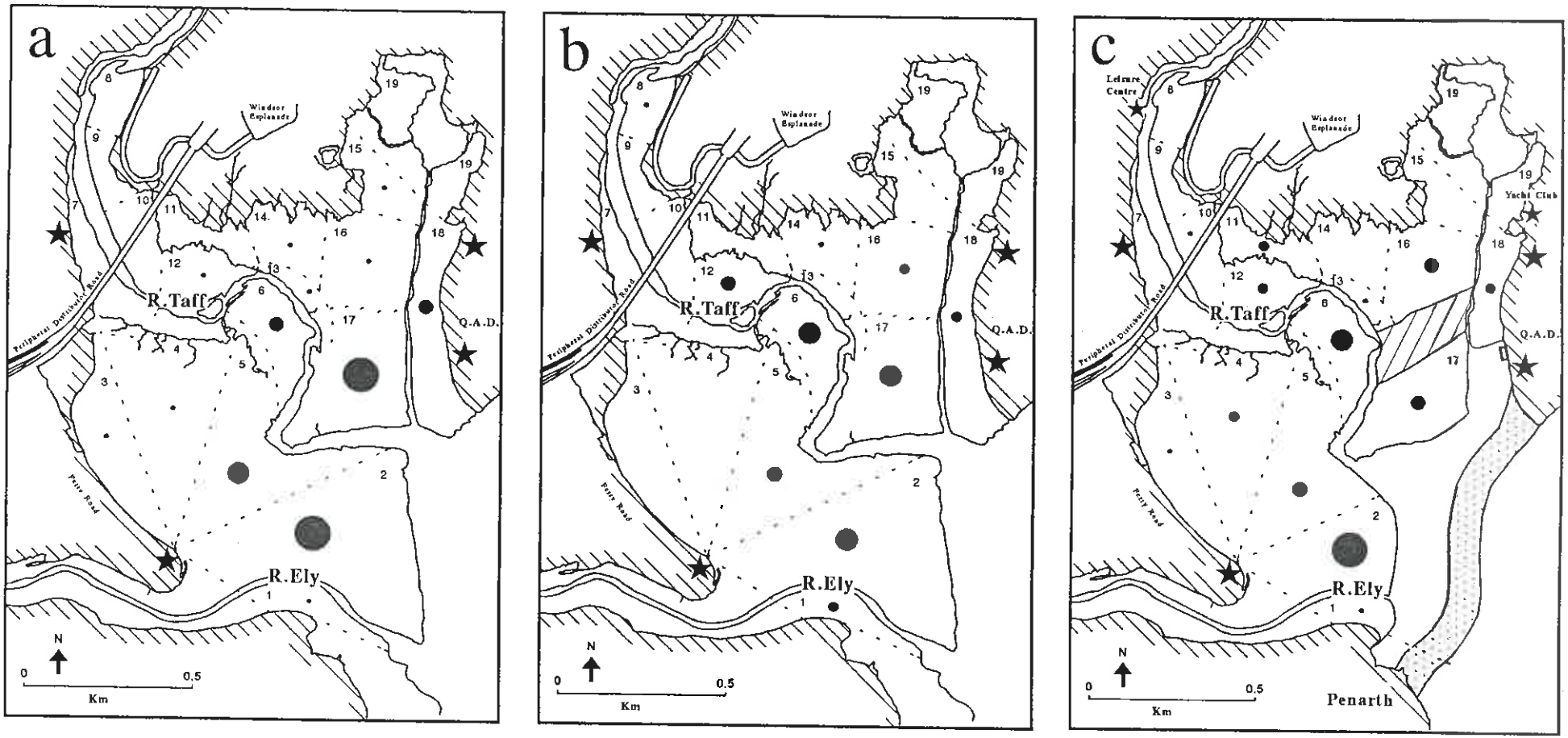


Figure 3.3.5
The distribution of feeding Curlew on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	·	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

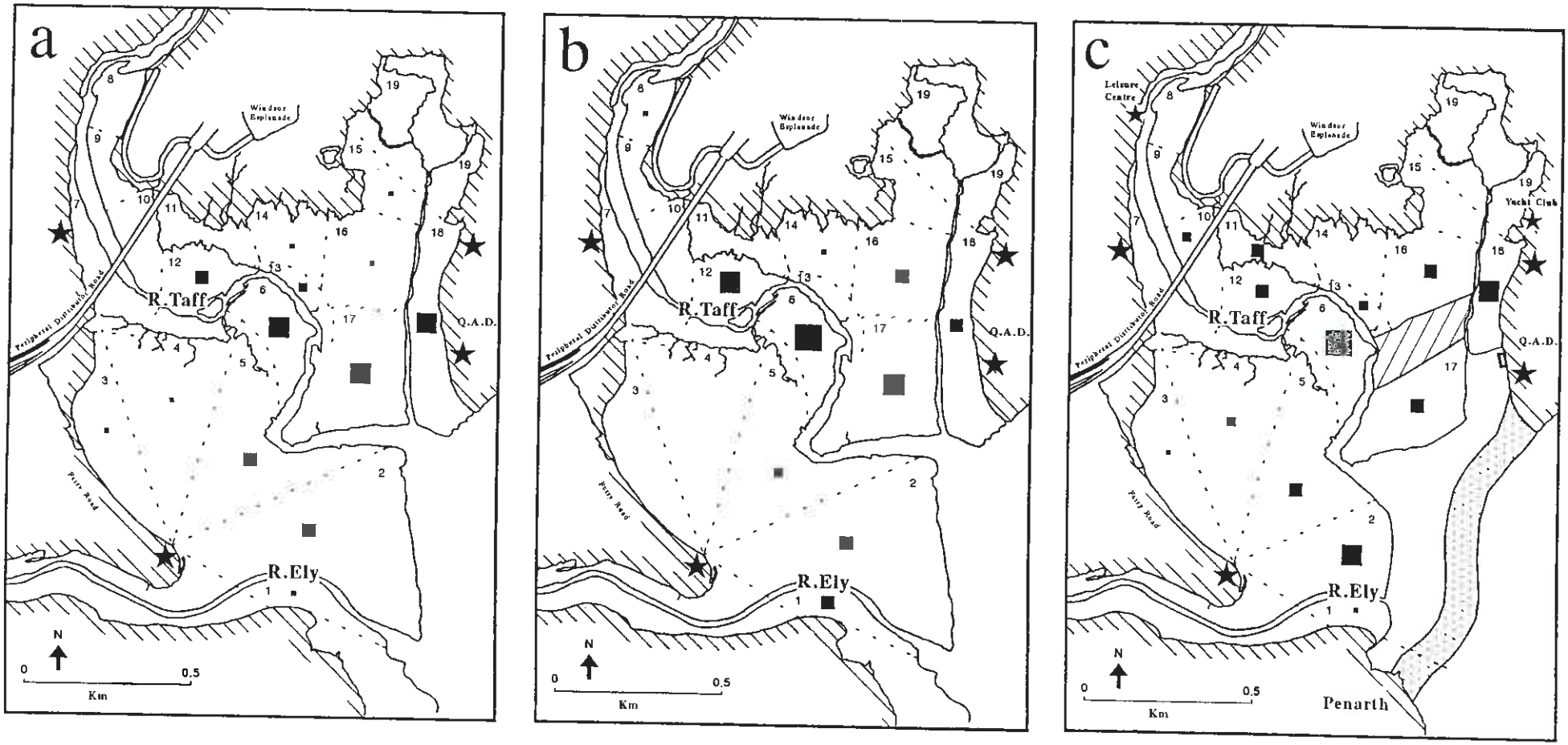


Figure 3.3.6
The distribution of feeding Curlew on the Taff/Ely all day site during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

0.1-0.4	▪	2.5-4.9	■
0.5-0.9	▪	5.0-9.9	■
1.0-2.4	■	>10.0	■

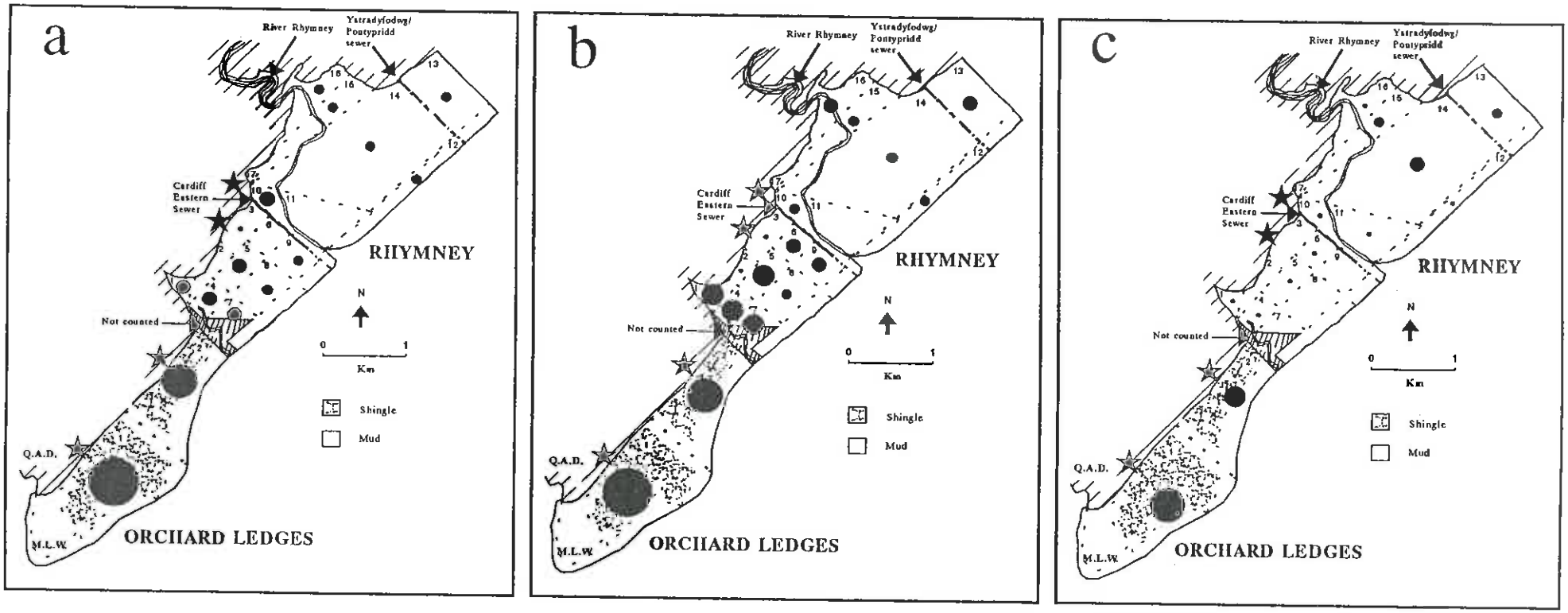


Figure 3.3.7
The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

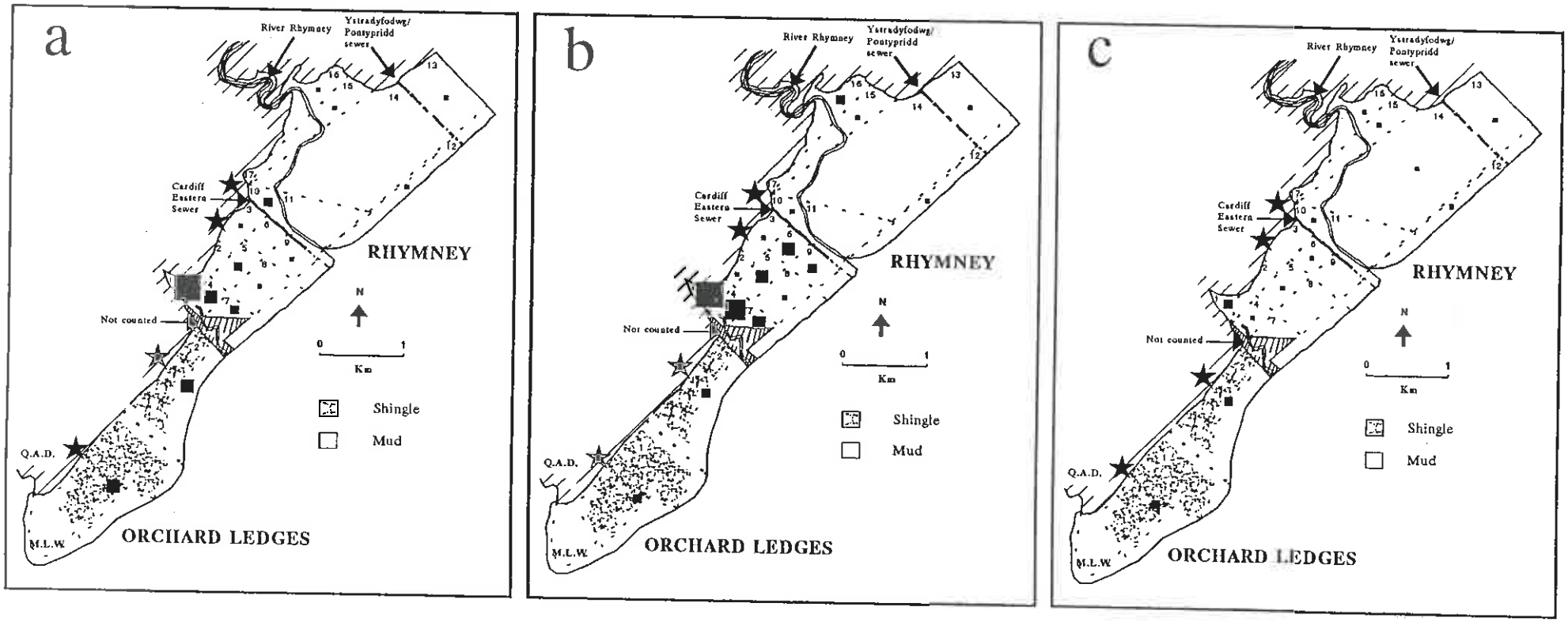


Figure 3.3.8
The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day sites during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

0.1-0.4	·	2.5-4.9	■
0.5-0.9	▪	5.0-9.9	■
1.0-2.4	■	>10.0	■

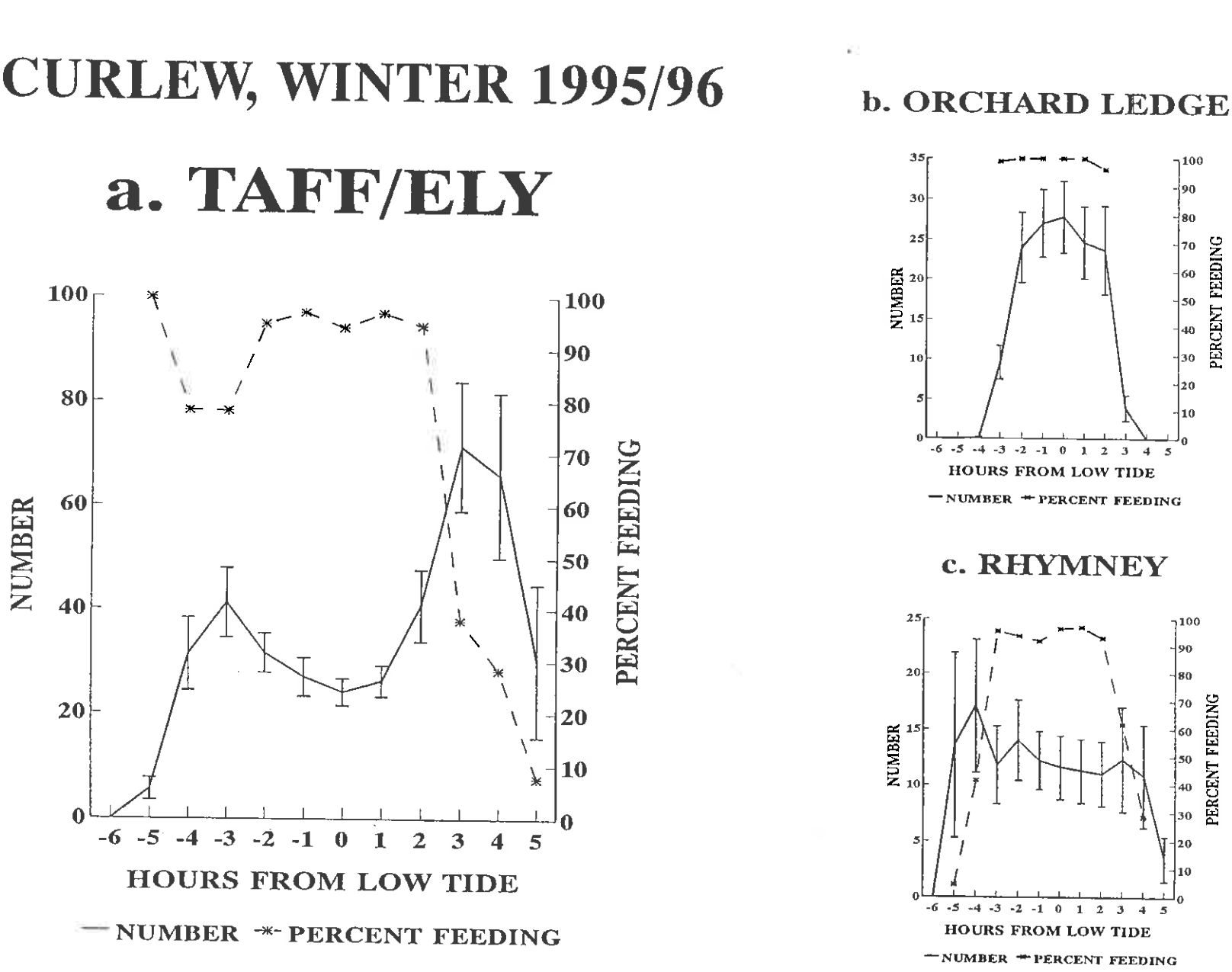


Figure 3.3.9 The total number of Curlew present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

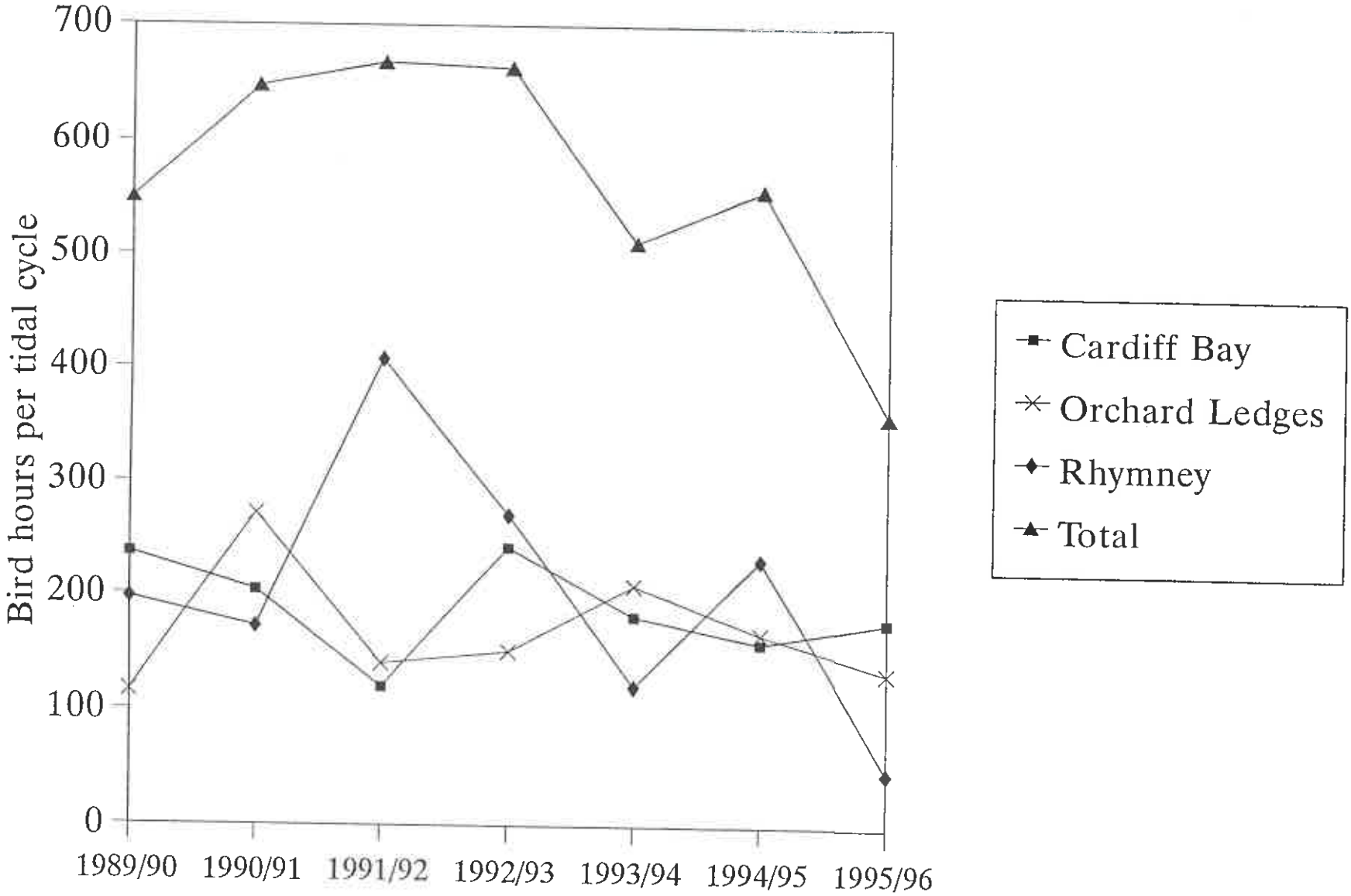


Figure 3.3.10 The all-day usage of the three study sites by Curlew between 1989/90 and 1995/96.

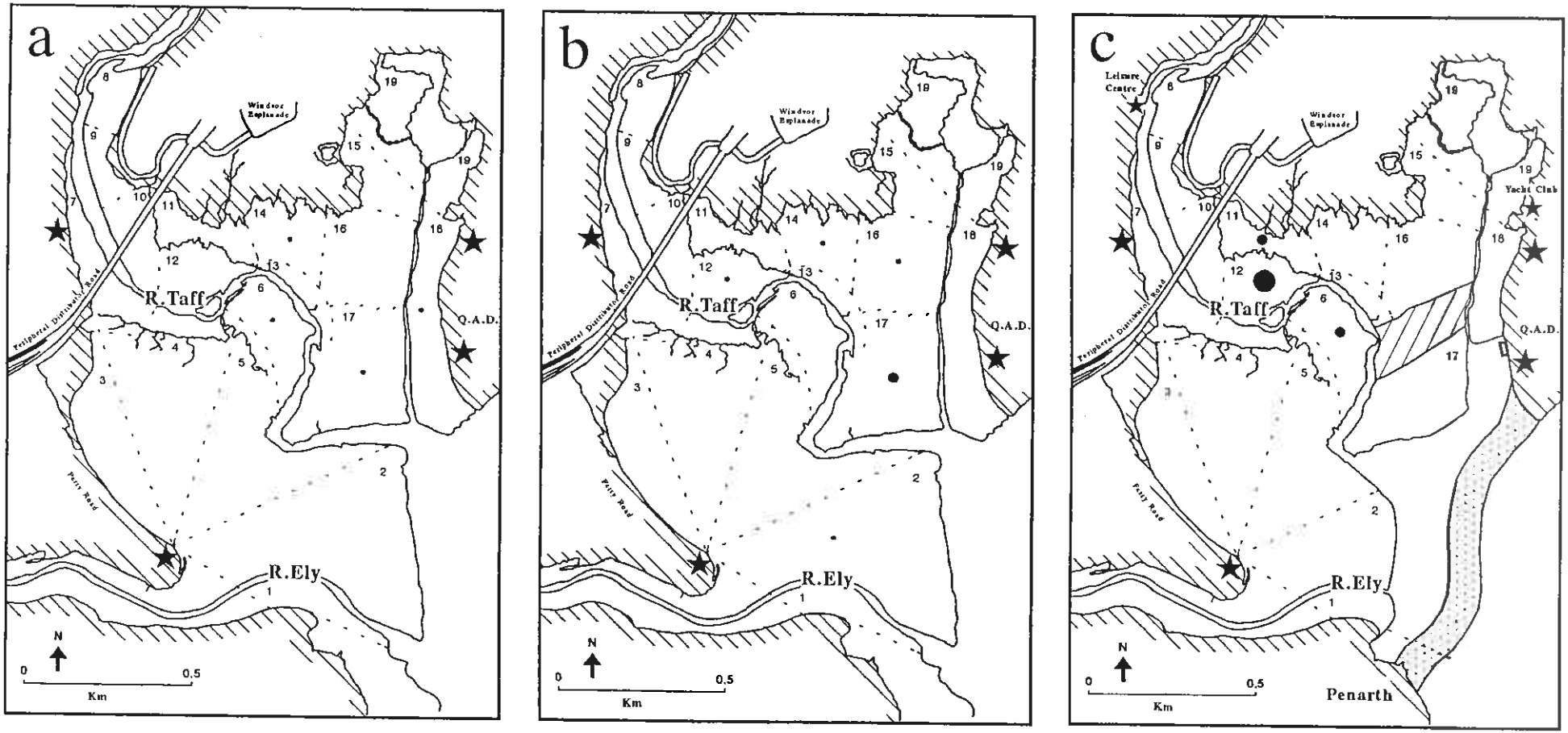
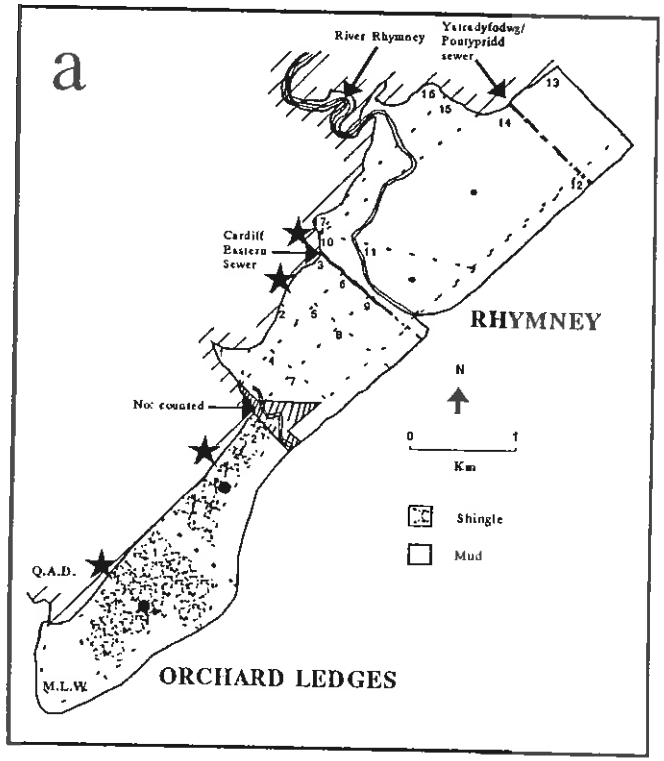


Figure 3.3.11
The distribution of feeding Curlew on the Taff/Ely all day site during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1995; c = 1996.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●



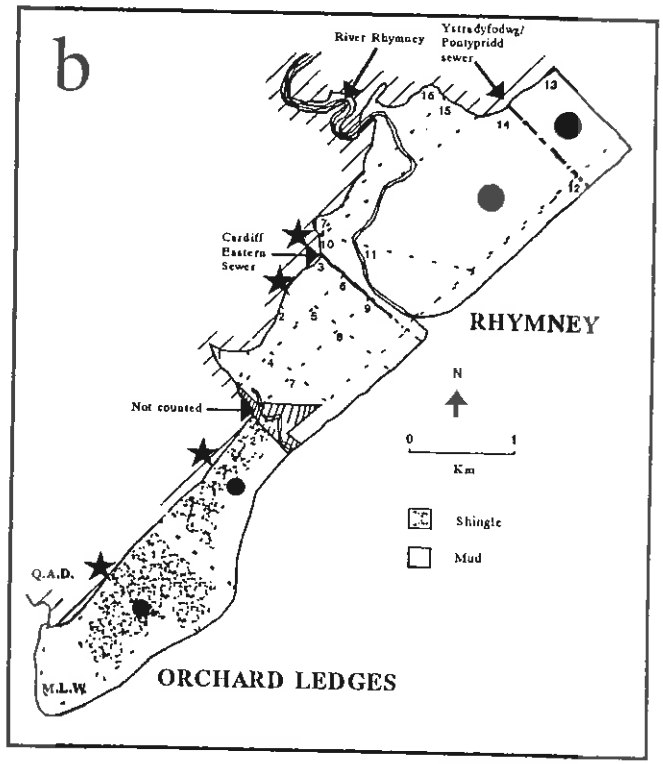


Figure 3.3.12
The distribution of feeding Curlew on the Rhymney and Orchard Ledges all day sites during spring. The average number of bird hours per tidal cycle is depicted.
a = 1994; b = 1996.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	•	>100	●

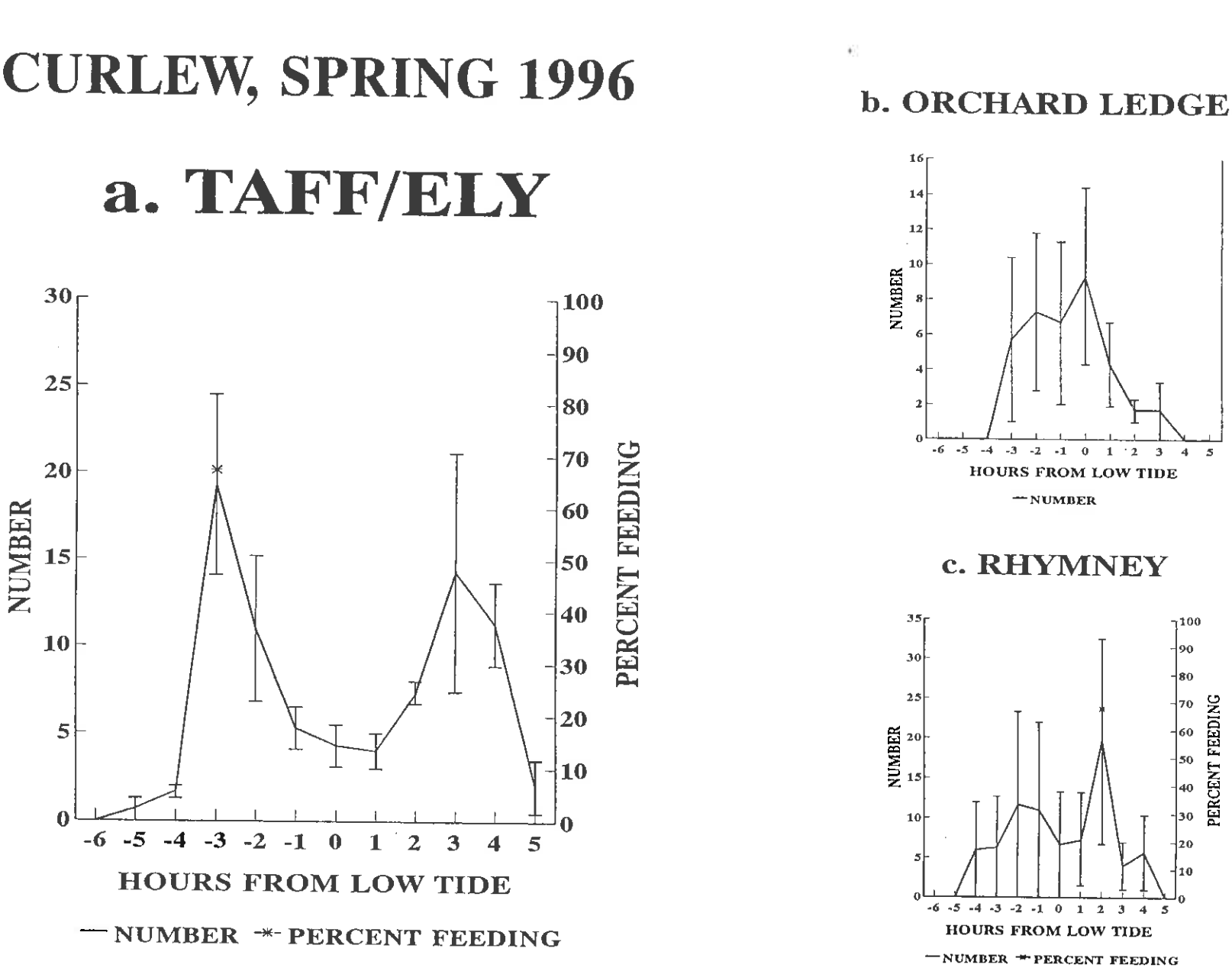


Figure 3.3.13 The total number of Curlew present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during spring 1996.

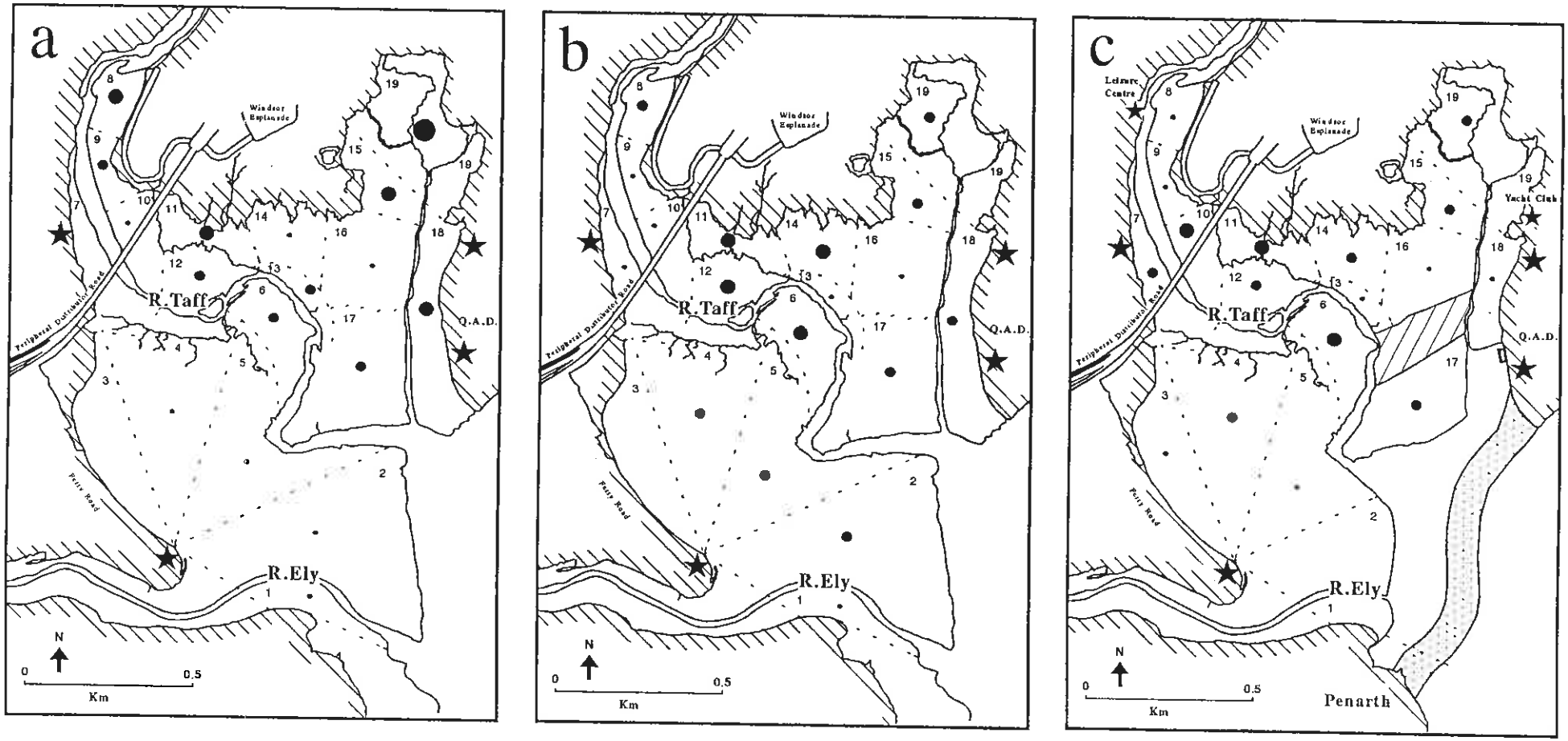


Figure 3.4.1
The distribution of feeding Redshank on the Taff/Ely all day site during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-24	•	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

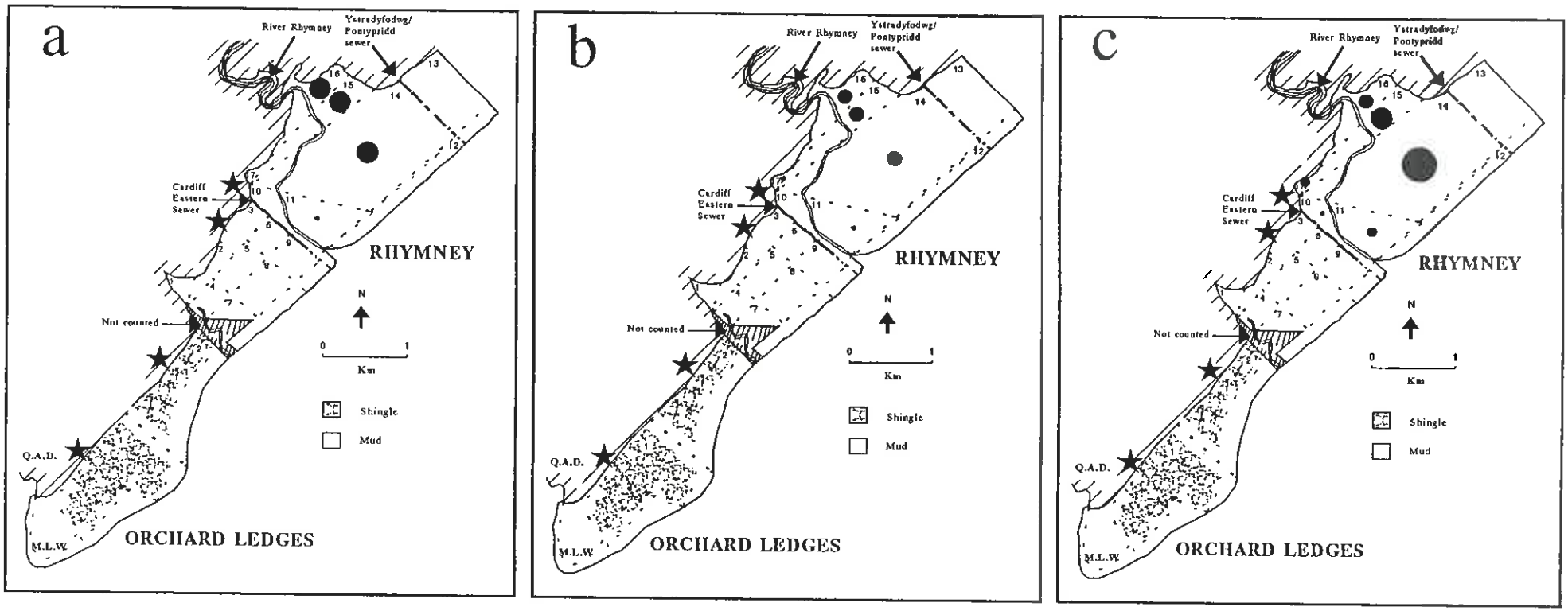


Figure 3.4.2
The distribution of feeding Redshank on the Rhymney and Orchard Ledges all day sites during autumn. The average number of bird hours per tidal cycle is depicted.
a = 1993; b = 1994; c = 1995.

Key

1-24	•	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

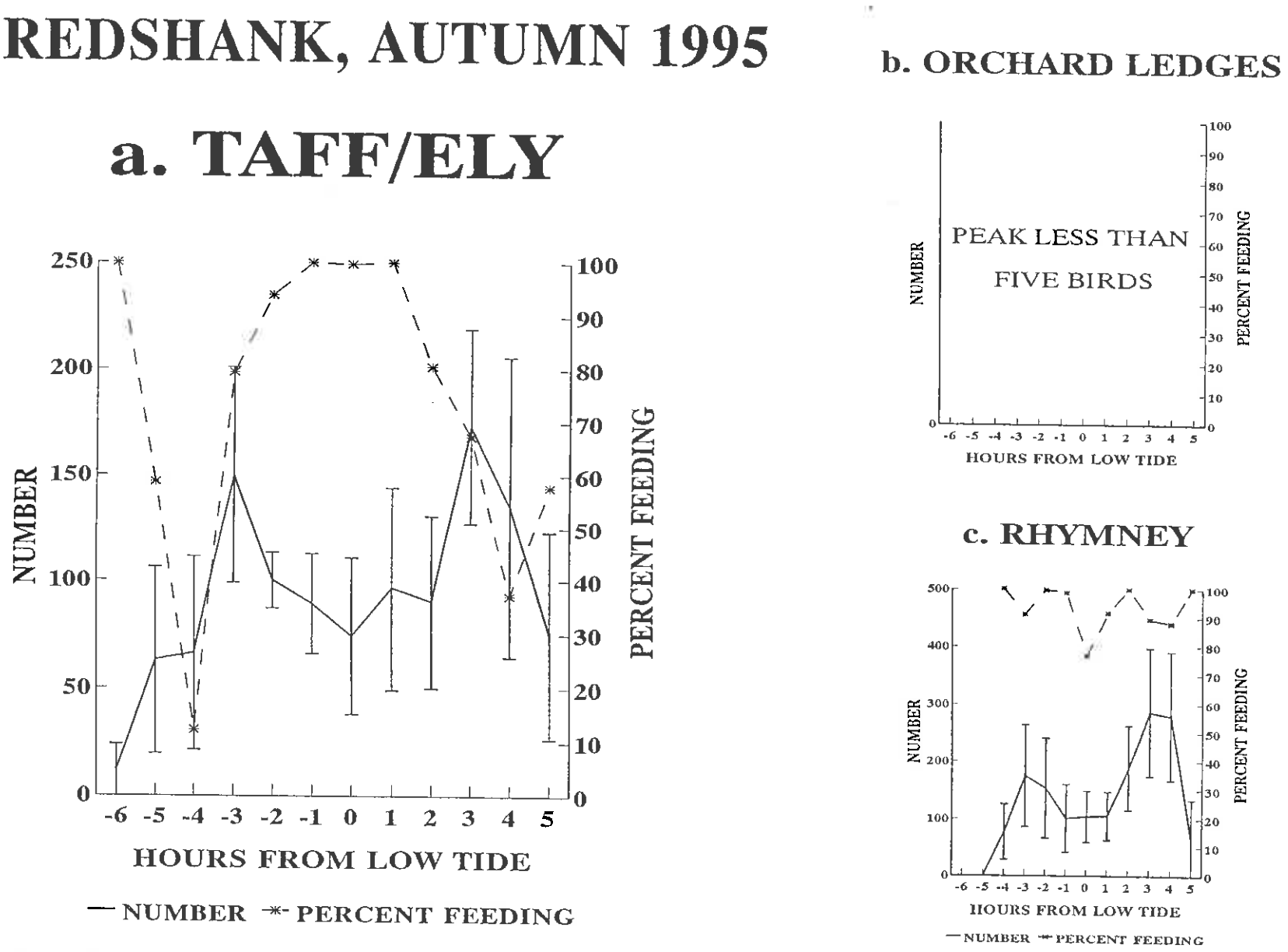


Figure 3.4.3 The total number of Redshank present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during autumn 1995.

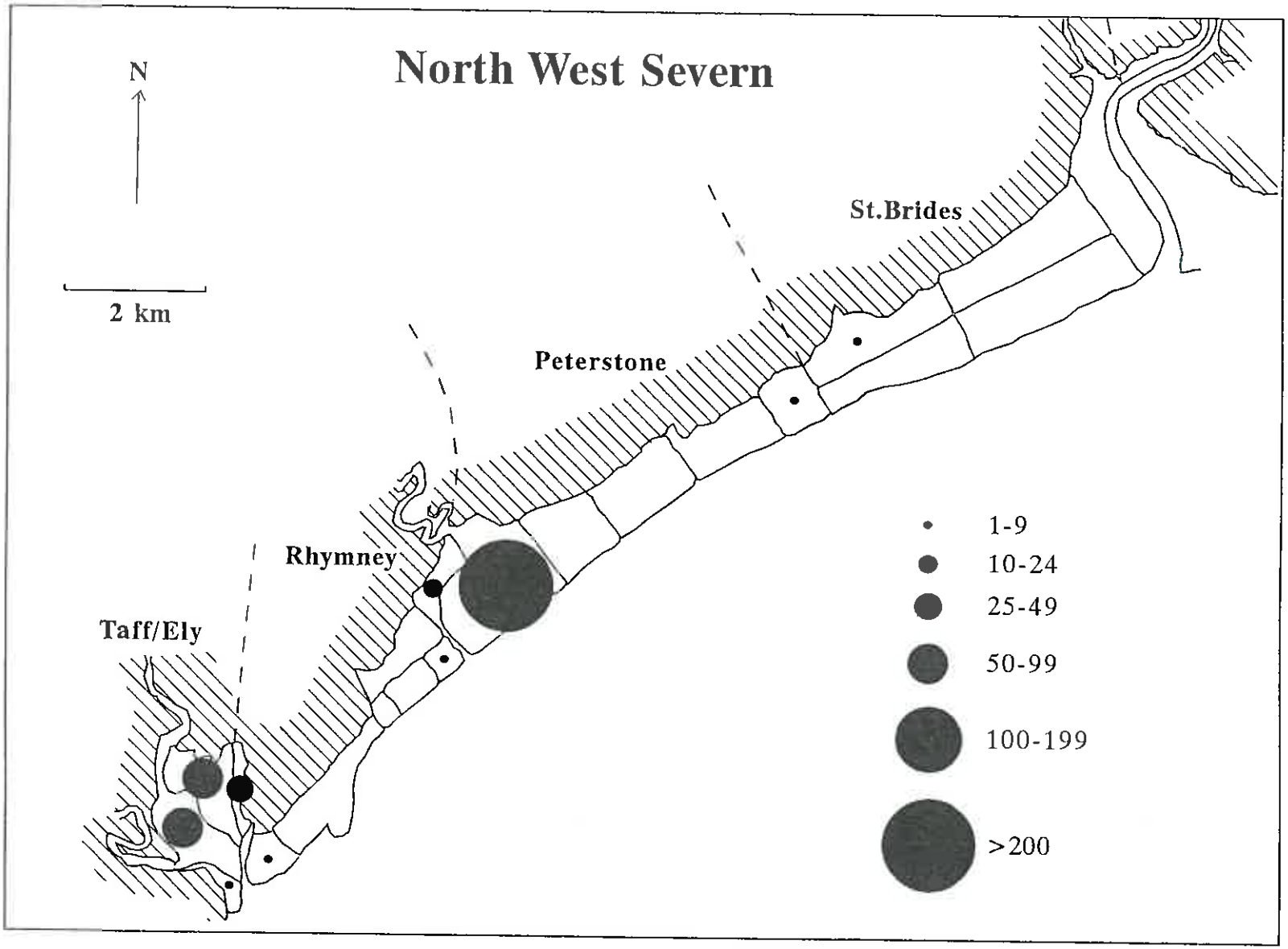


Figure 3.4.4 The low tide distribution of feeding Redshank on the northwest Severn during winter 1995/96.

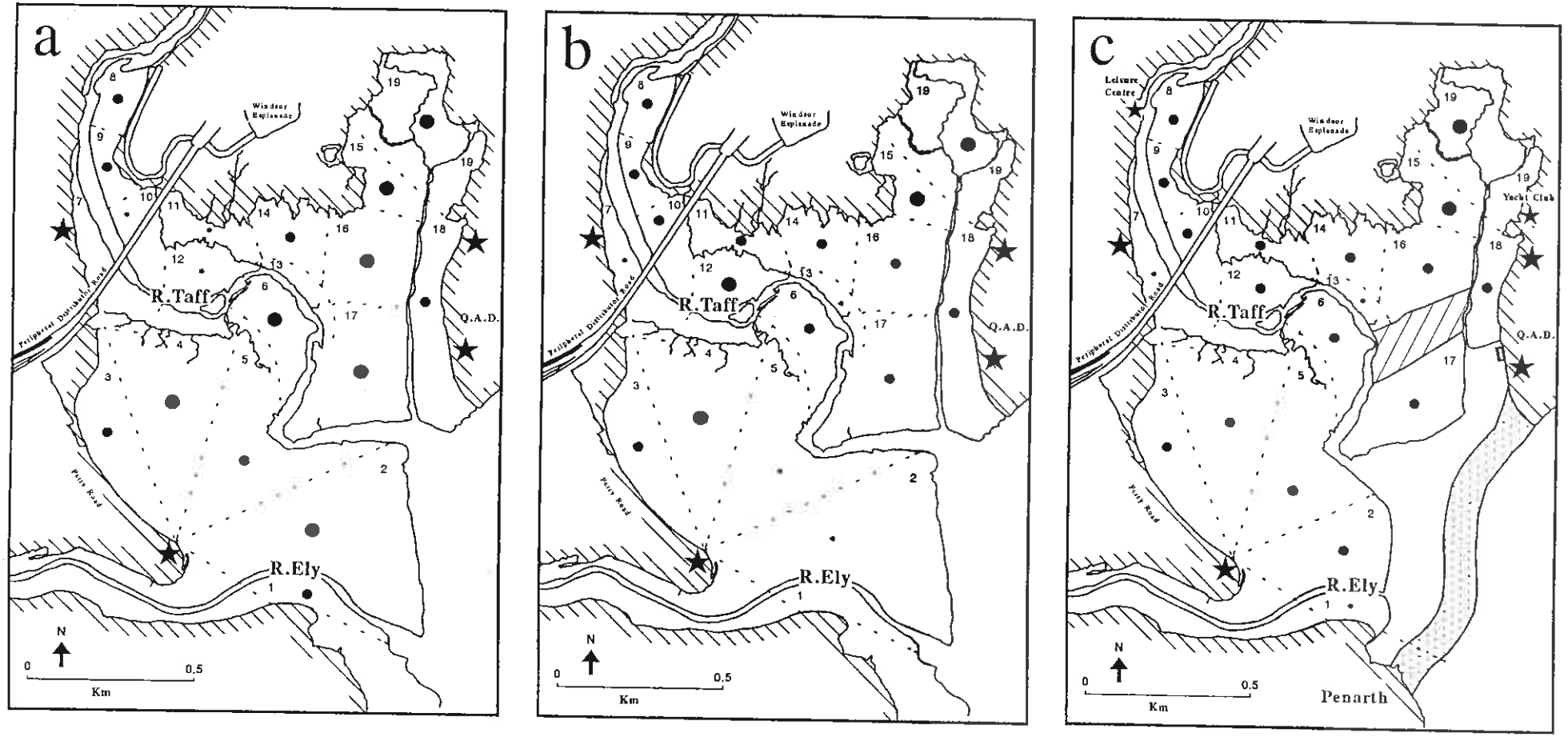


Figure 3.4.5
The distribution of feeding Redshank on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-24	·	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

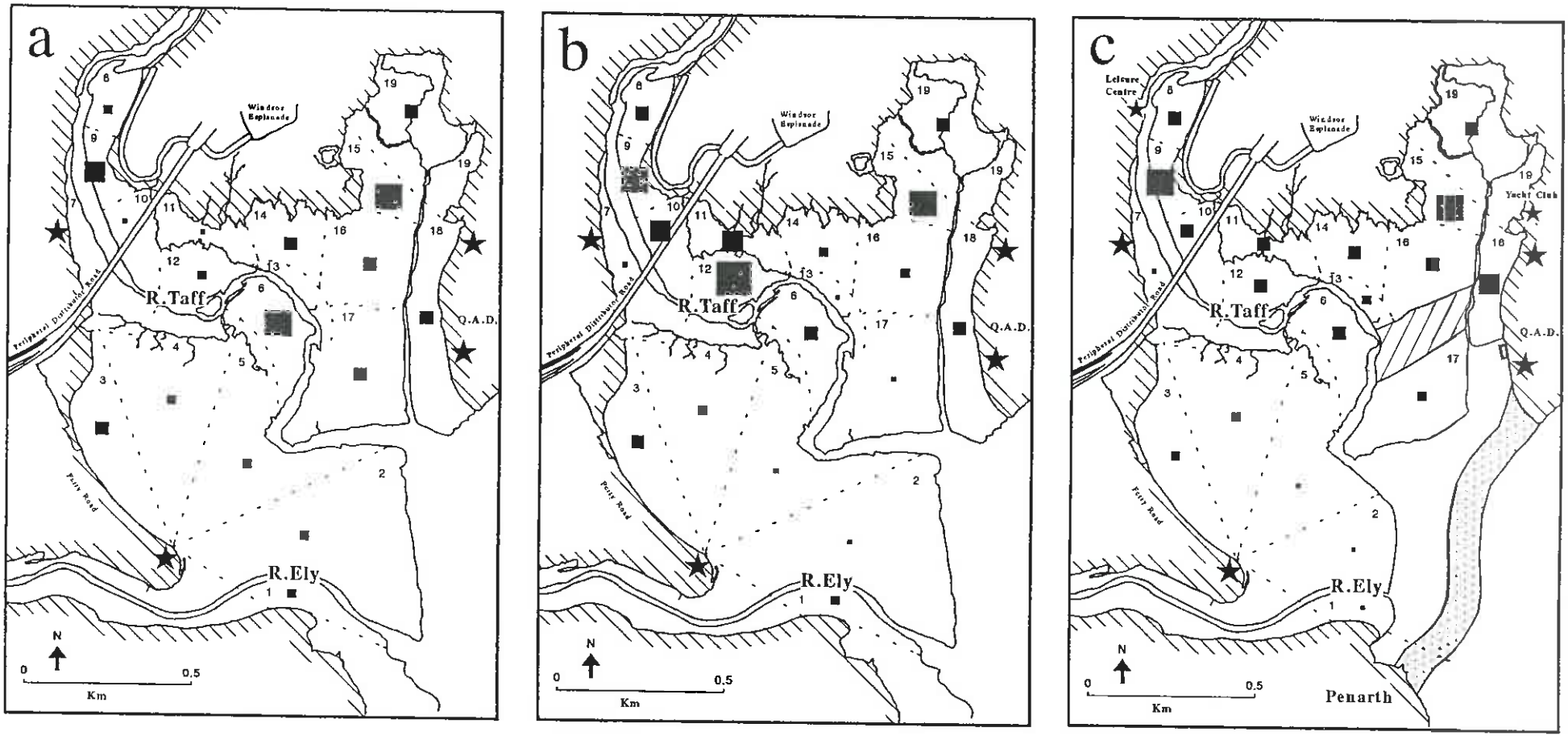


Figure 3.4.6
The distribution of feeding Redshank on the Taff/Ely all day site during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

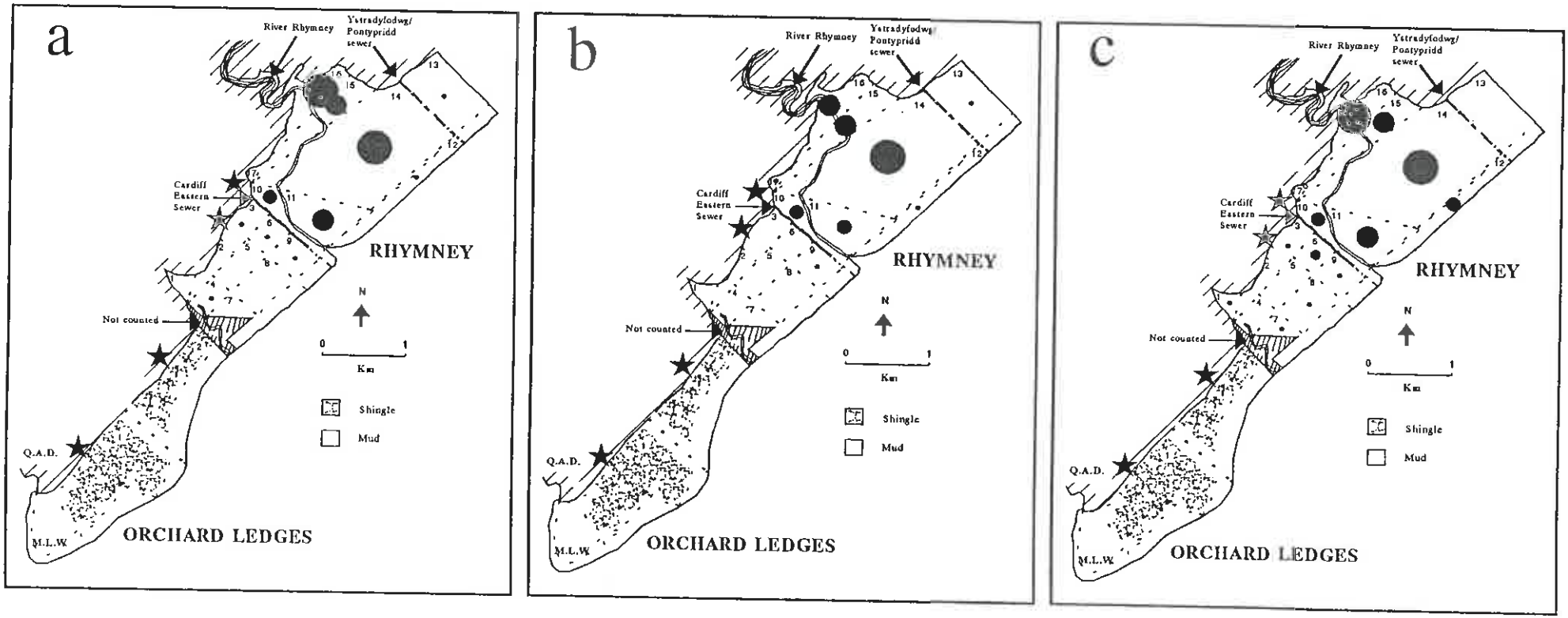


Figure 3.4.7
The distribution of feeding Redshank on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-24	•	250-499	●
25-99	•	500-999	●
100-249	●	>1000	●

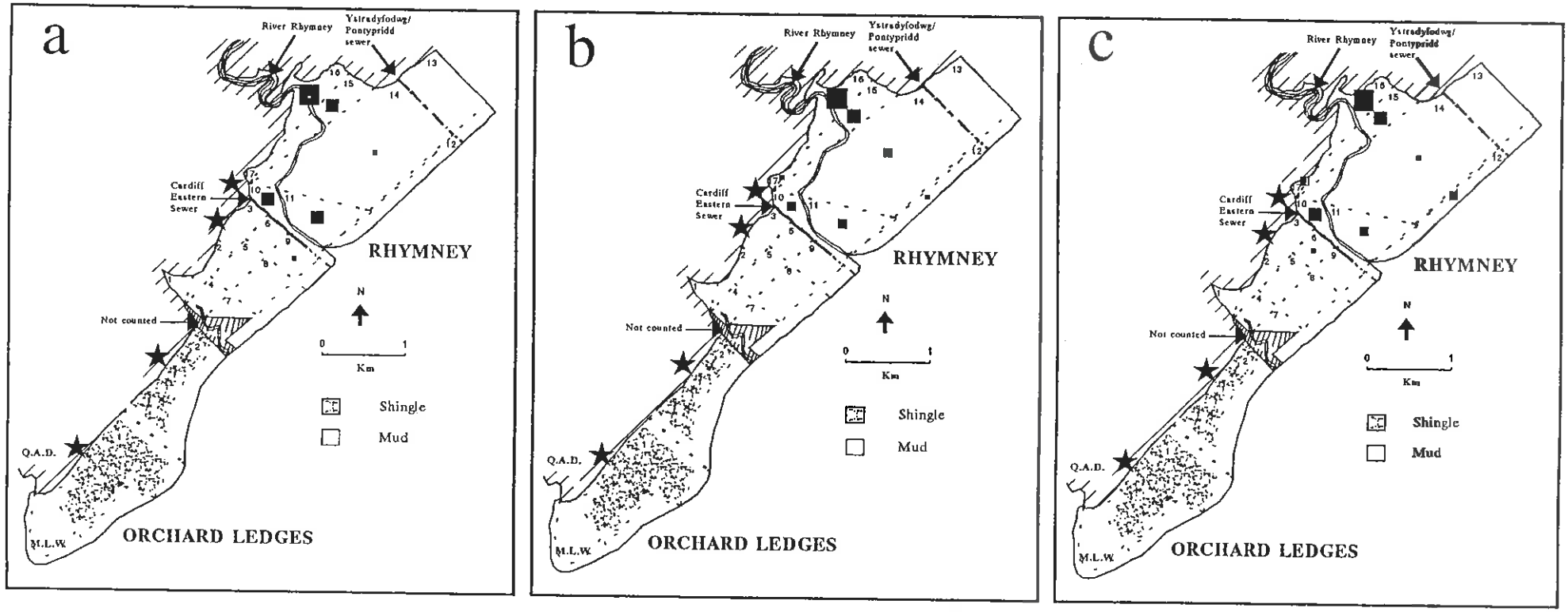


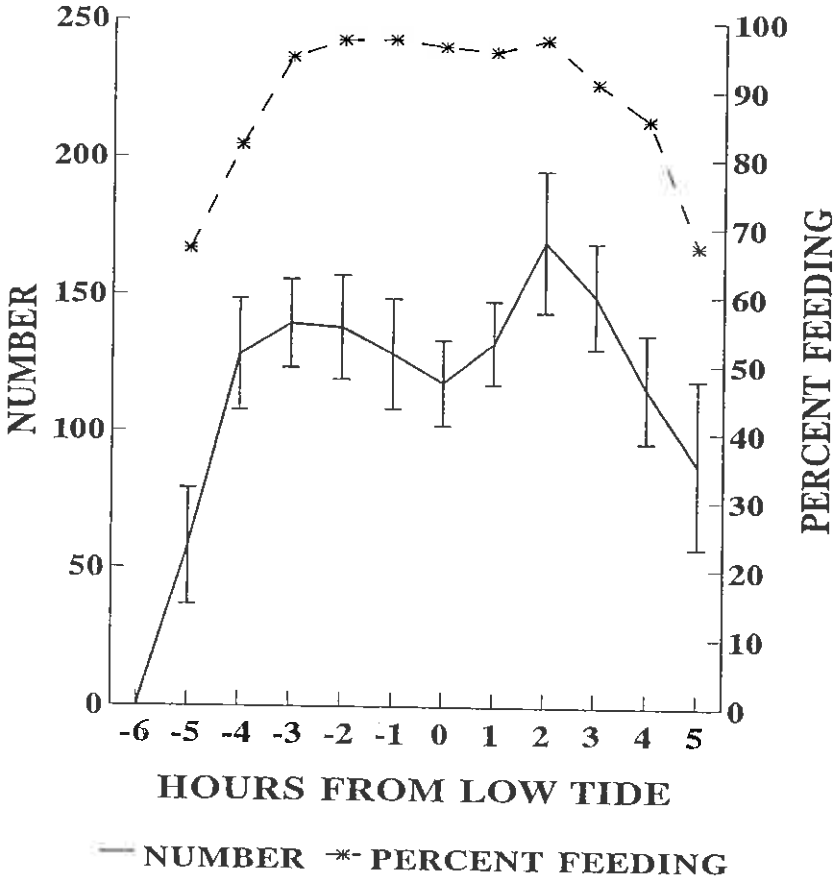
Figure 3.4.8
The distribution of feeding Redshank on the Rhymney and Orchard Ledges all day sites during winter. The mean feeding usage density (number of bird hours per tidal cycle per hectare) is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

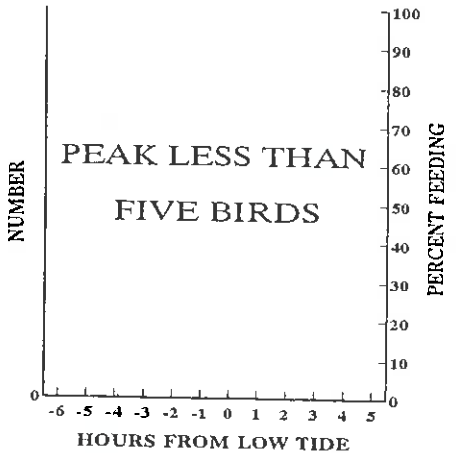
1-4	▪	20-29	■
5-9	▪	30-49	■
10-19	■	>50	■

REDSHANK, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

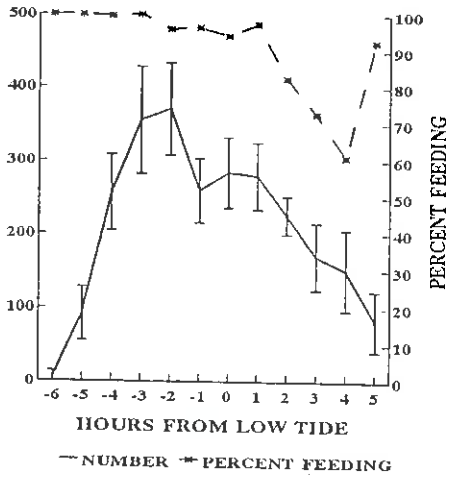


Figure 3.4.9 The total number of Redshank present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

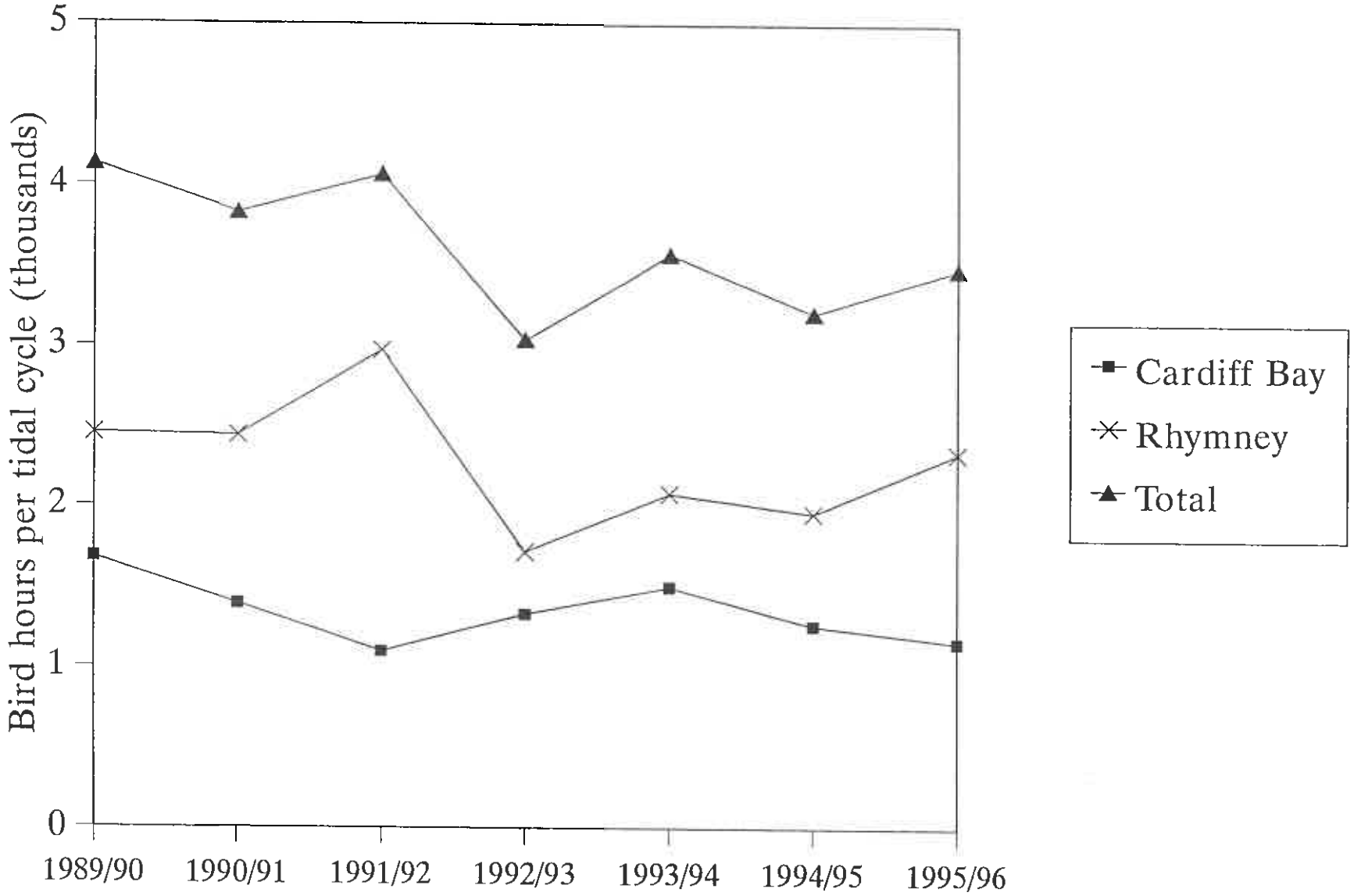


Figure 3.4.10 The all-day usage of the three study sites by Redshank between 1989/90 and 1995/96.

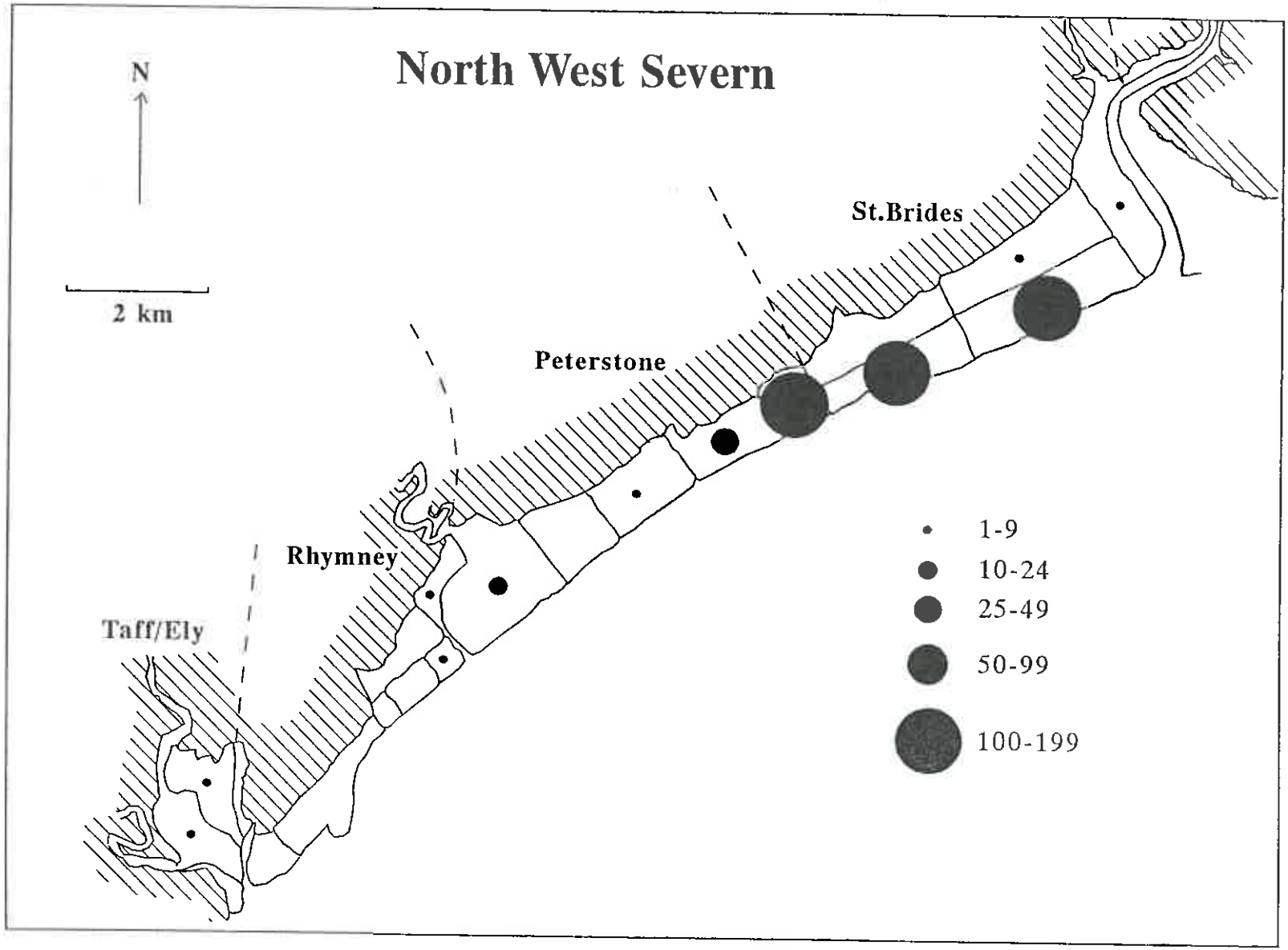


Figure 3.5.1.1 The low tide distribution of feeding Mallard on the northwest Severn during winter 1995/96.

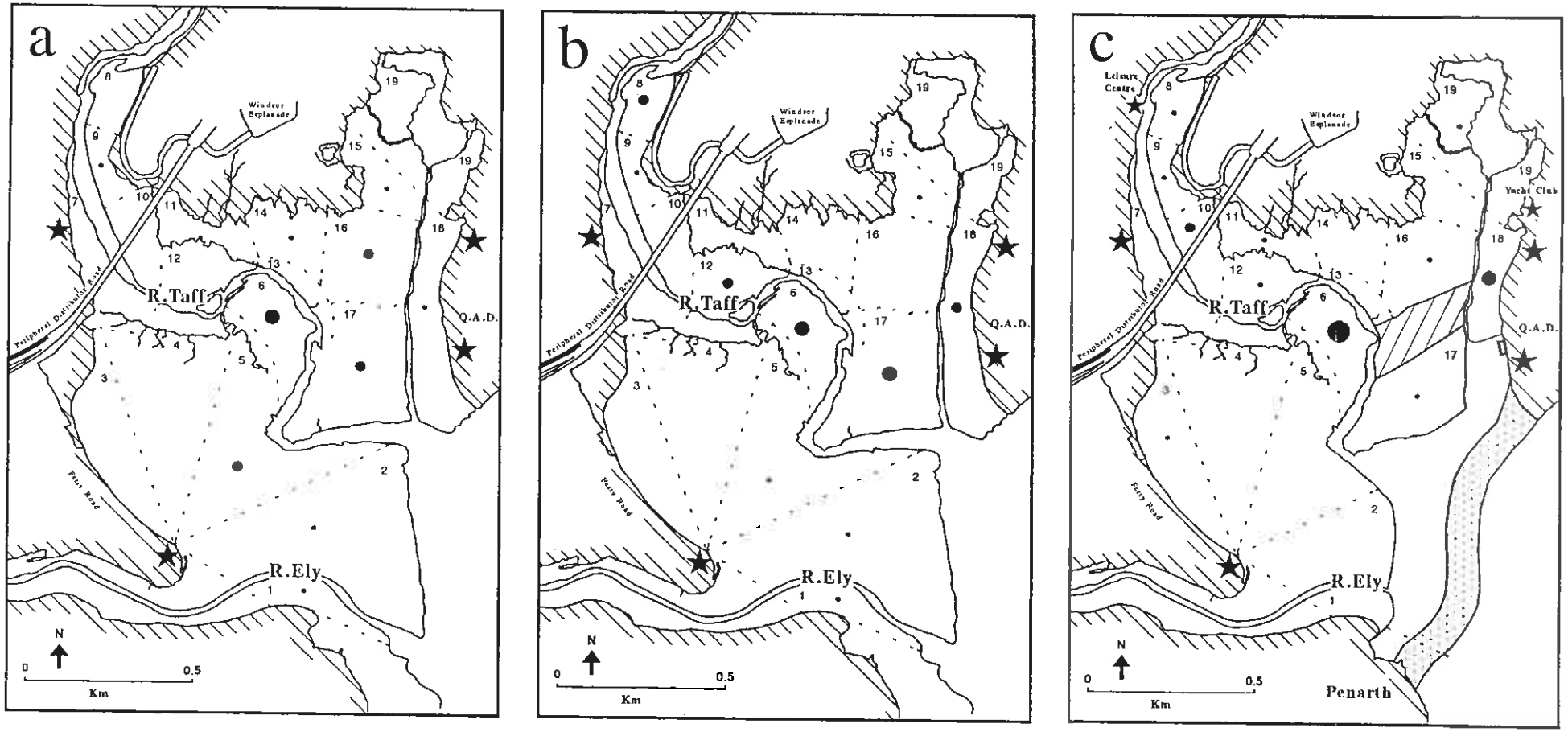


Figure 3.5.1.2
The distribution of feeding Mallard on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

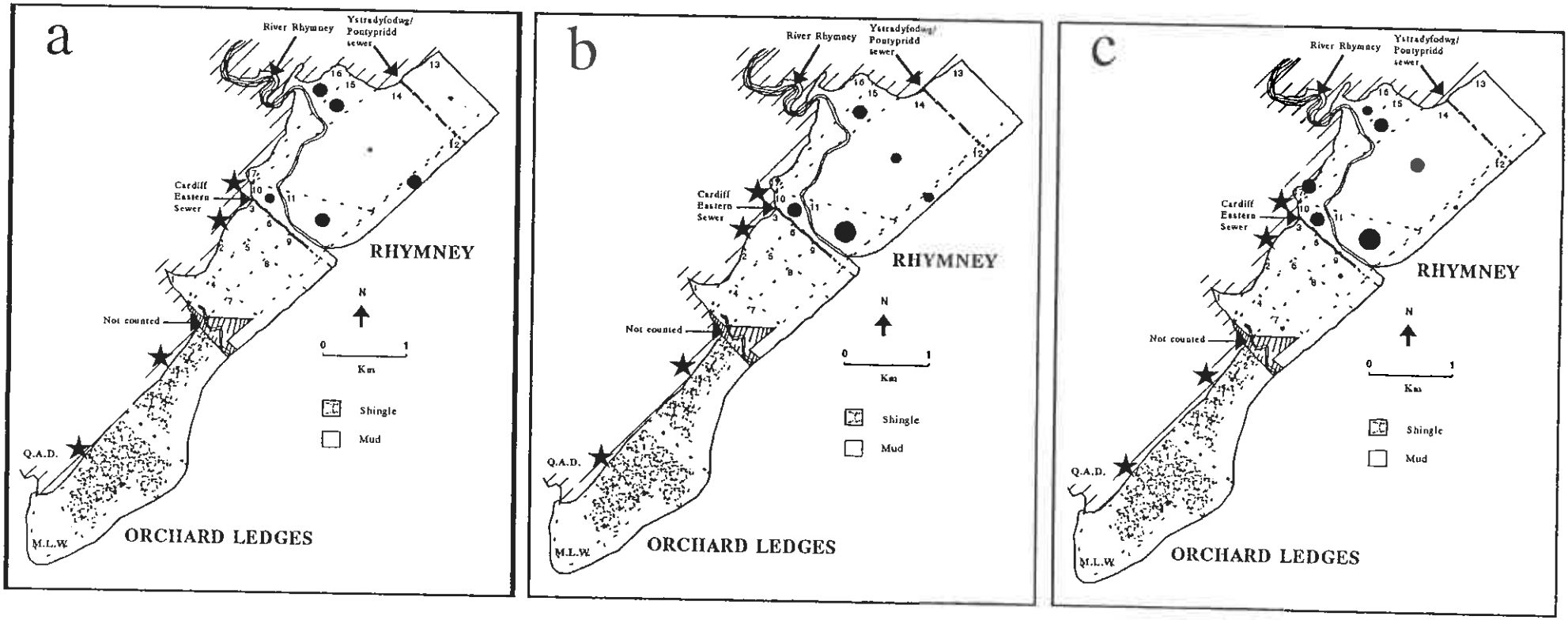


Figure 3.5.1.3
The distribution of feeding Mallard on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

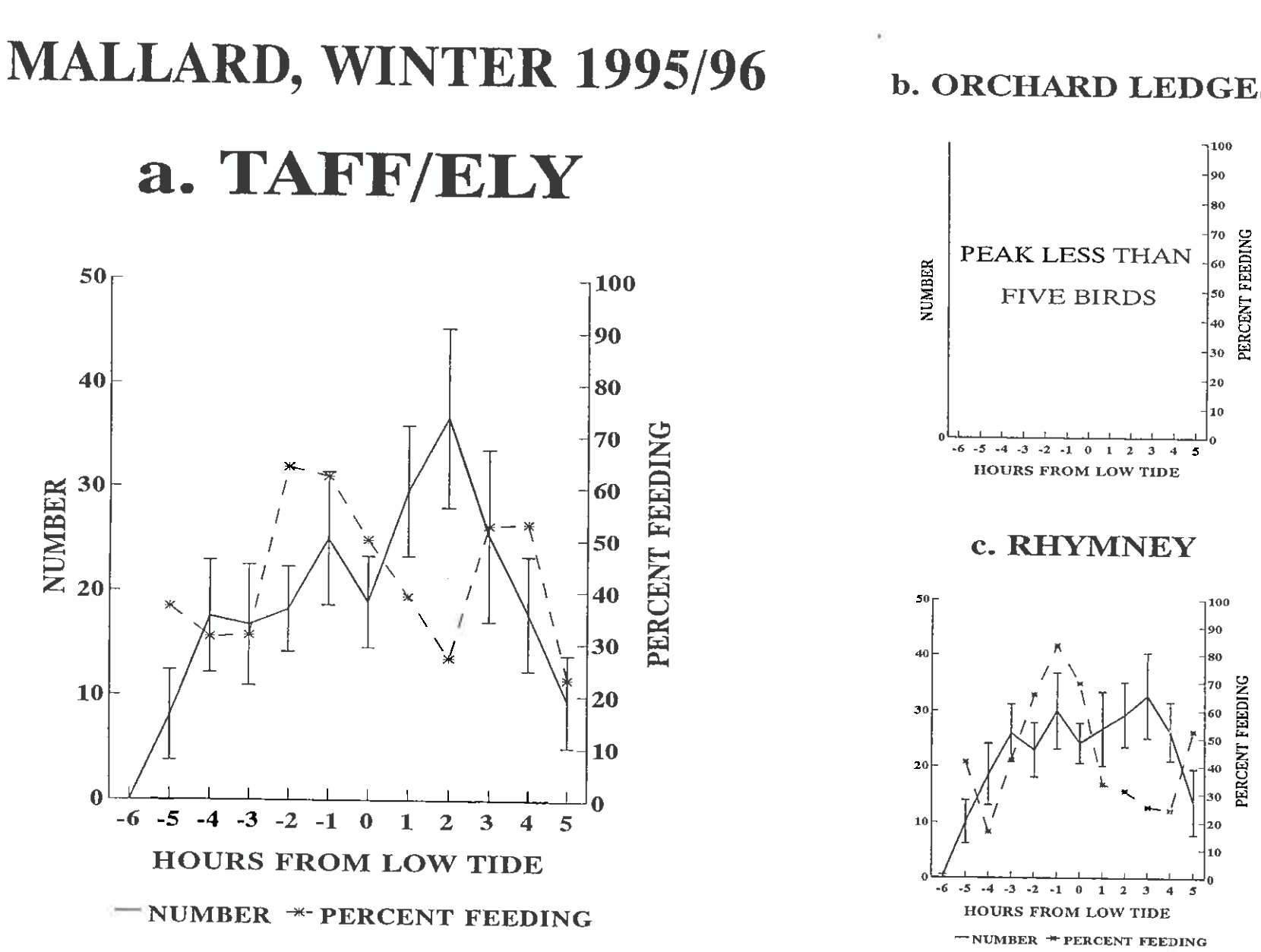


Figure 3.5.1.4 The total number of Mallard present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

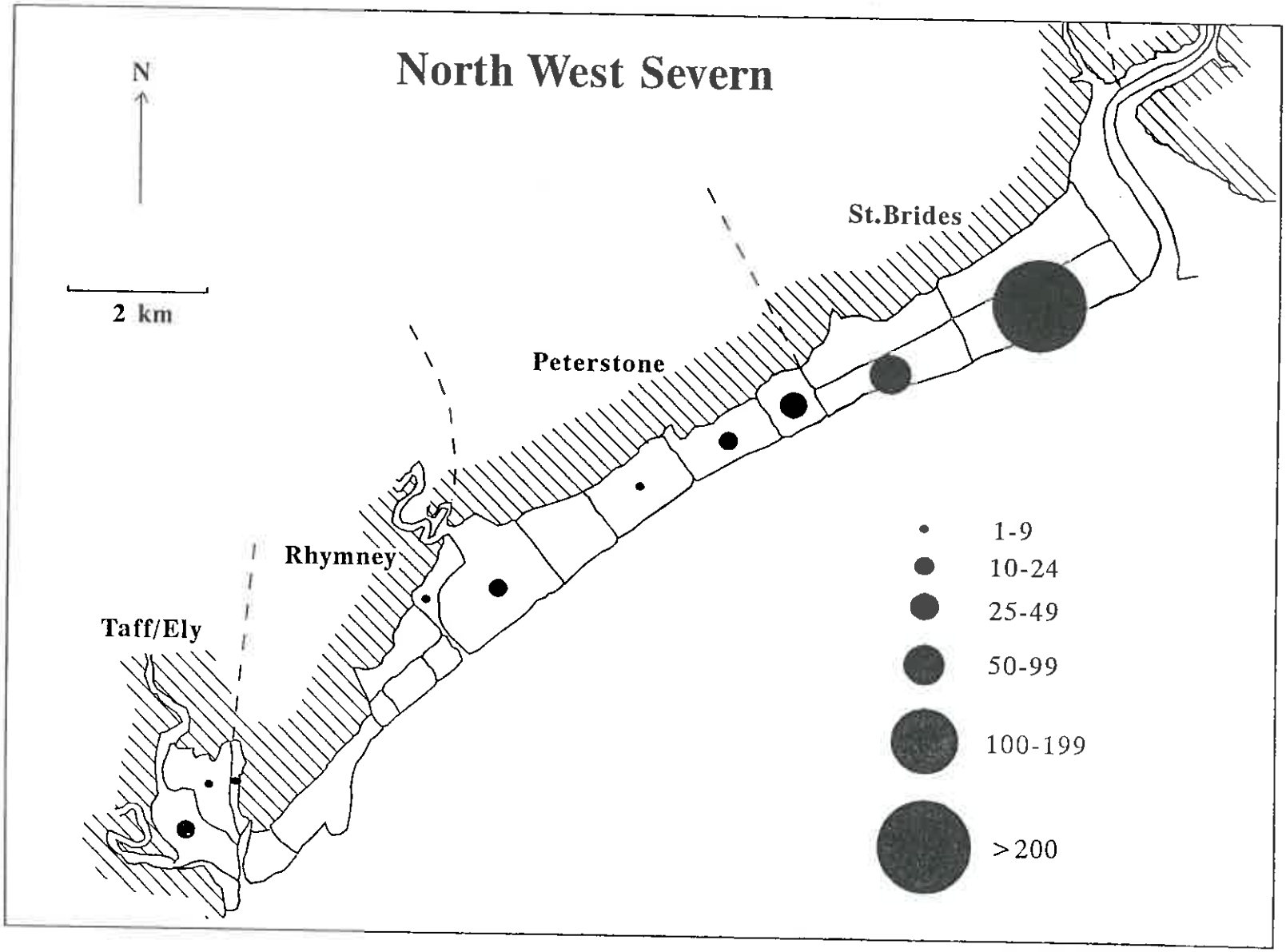


Figure 3.5.2.1 The low tide distribution of feeding Teal on the northwest Severn during winter 1995/96.

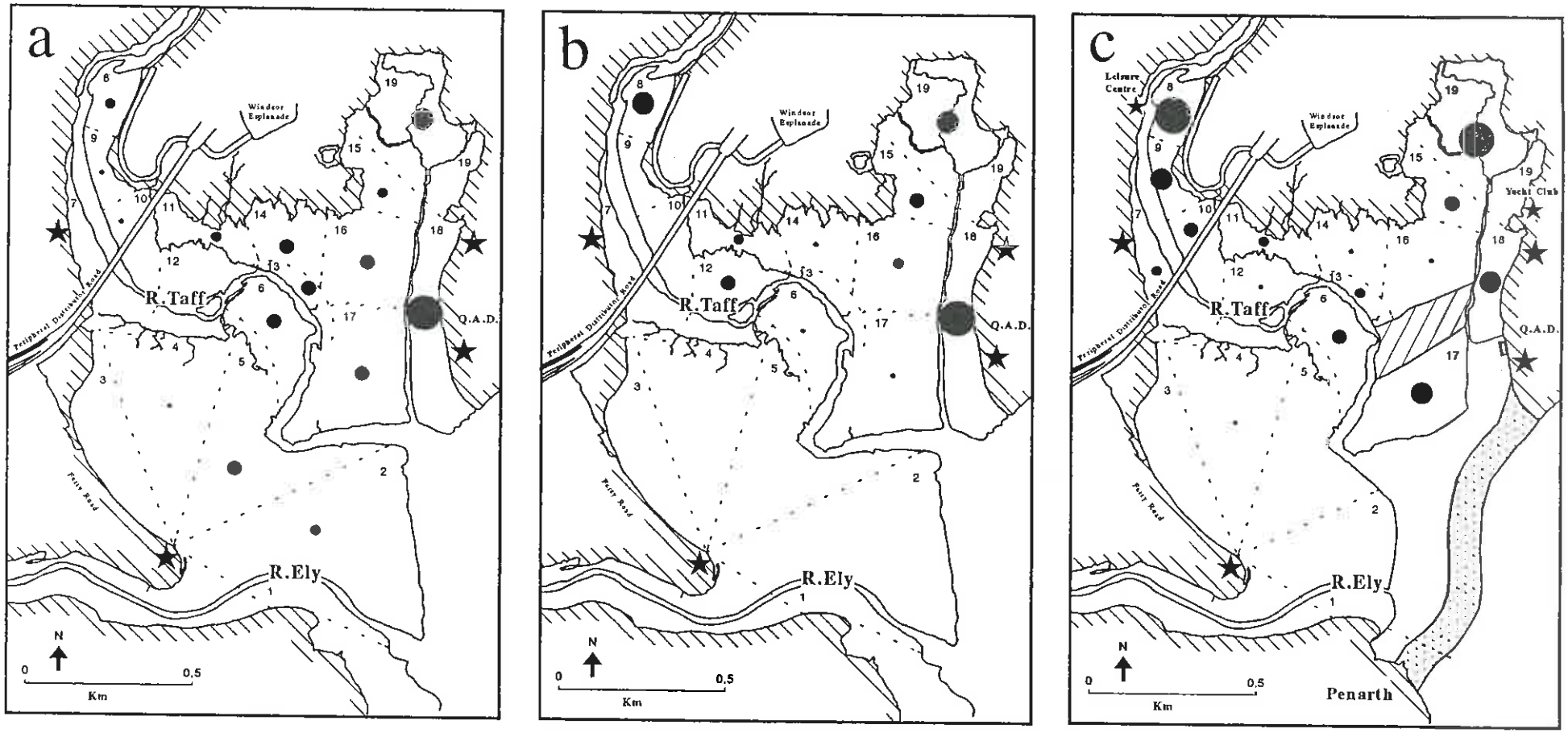


Figure 3.5.2.2
The distribution of feeding Teal on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	·	25-49	●
5-9	•	50-99	●
10-24	•	>100	●

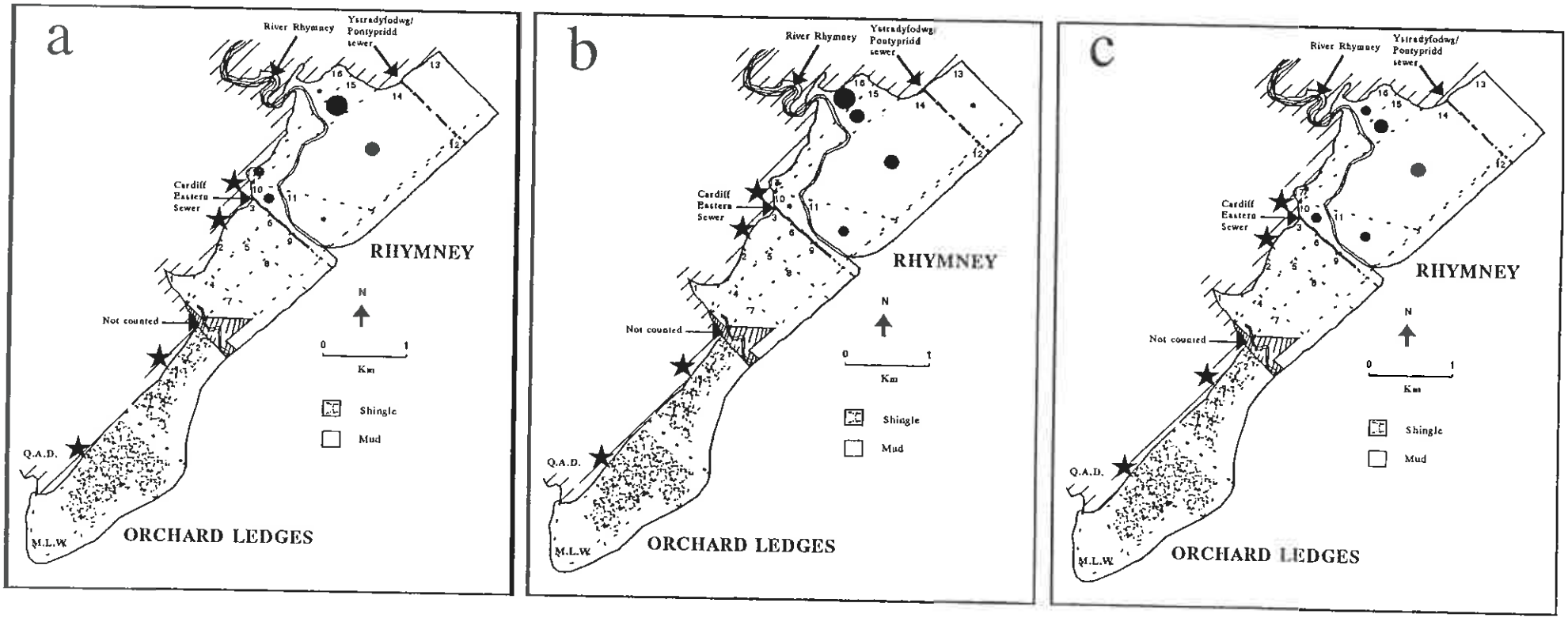


Figure 3.5.2.3
The distribution of feeding Teal on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

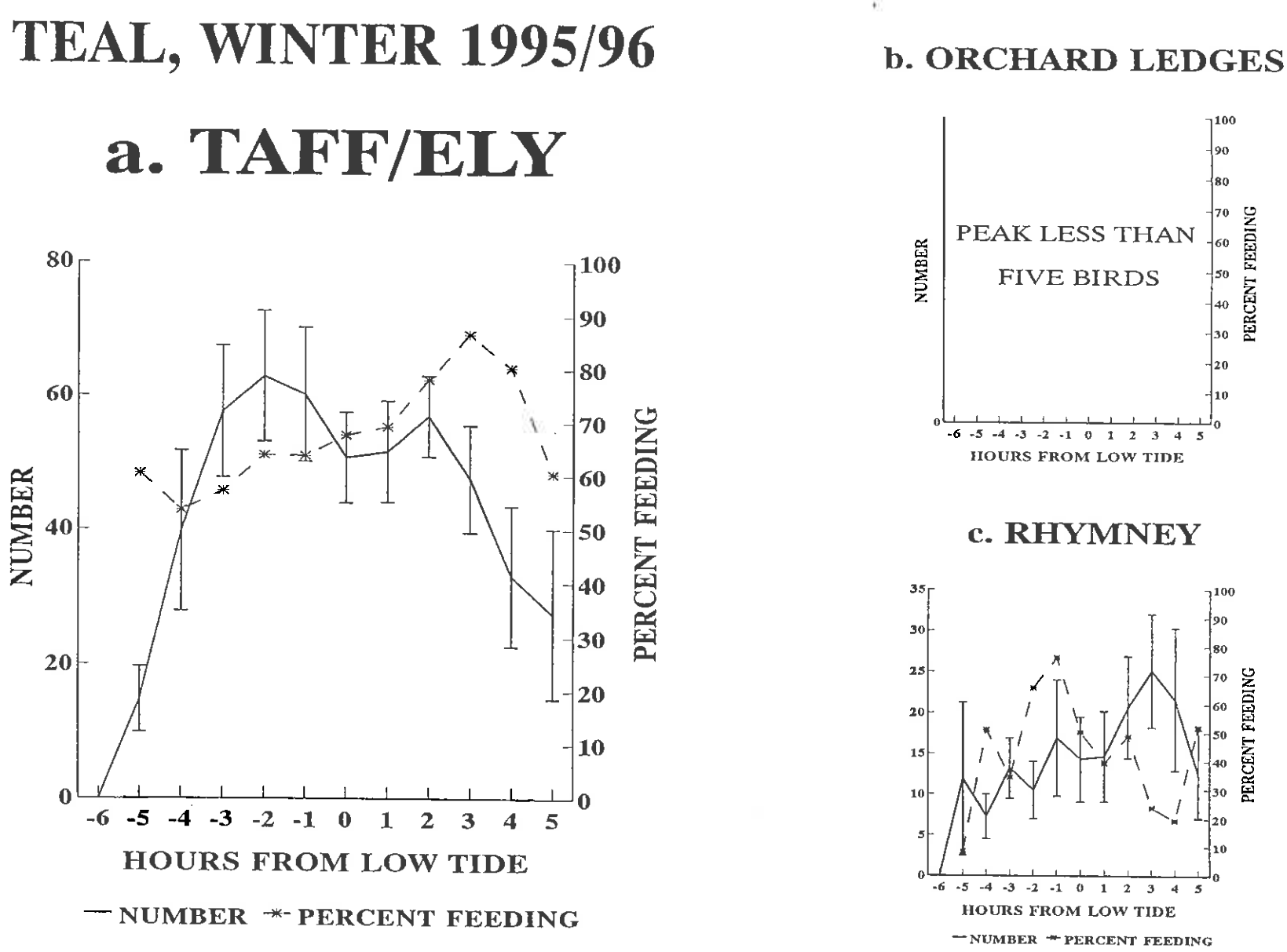


Figure 3.5.2.4 The total number of Teal present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

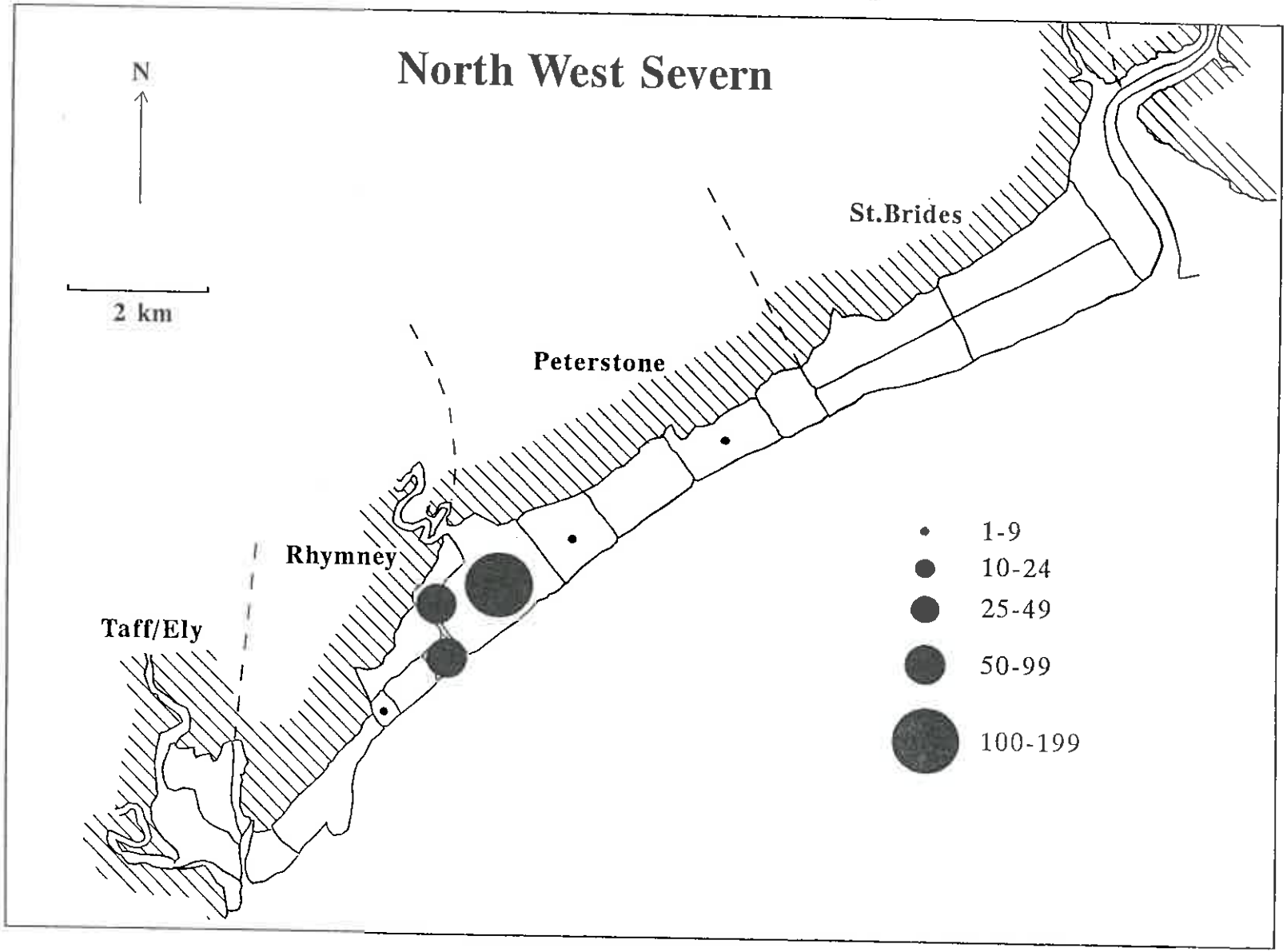


Figure 3.5.3.1 The low tide distribution of feeding Pintail on the northwest Severn during winter 1995/96.

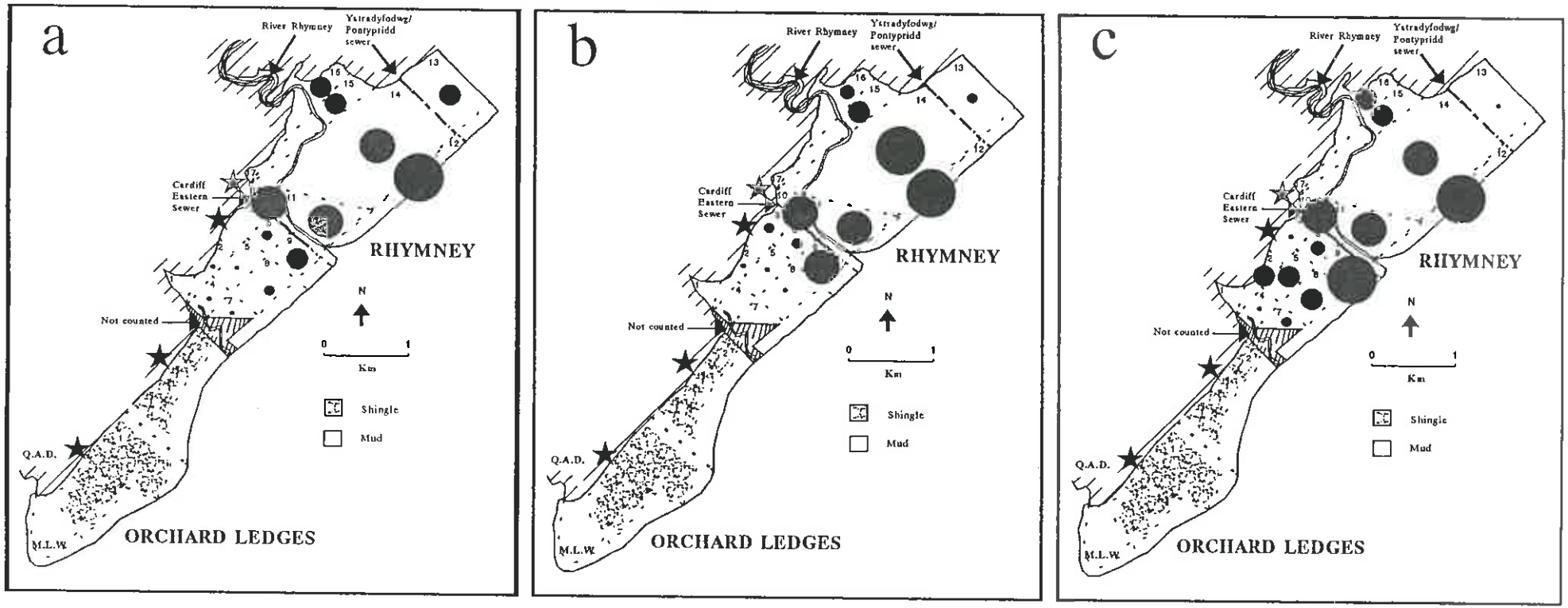


Figure 3.5.3.2
The distribution of feeding Pintail on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-9	•	50-99	●
10-24	•	100-199	●
25-49	•	>200	●

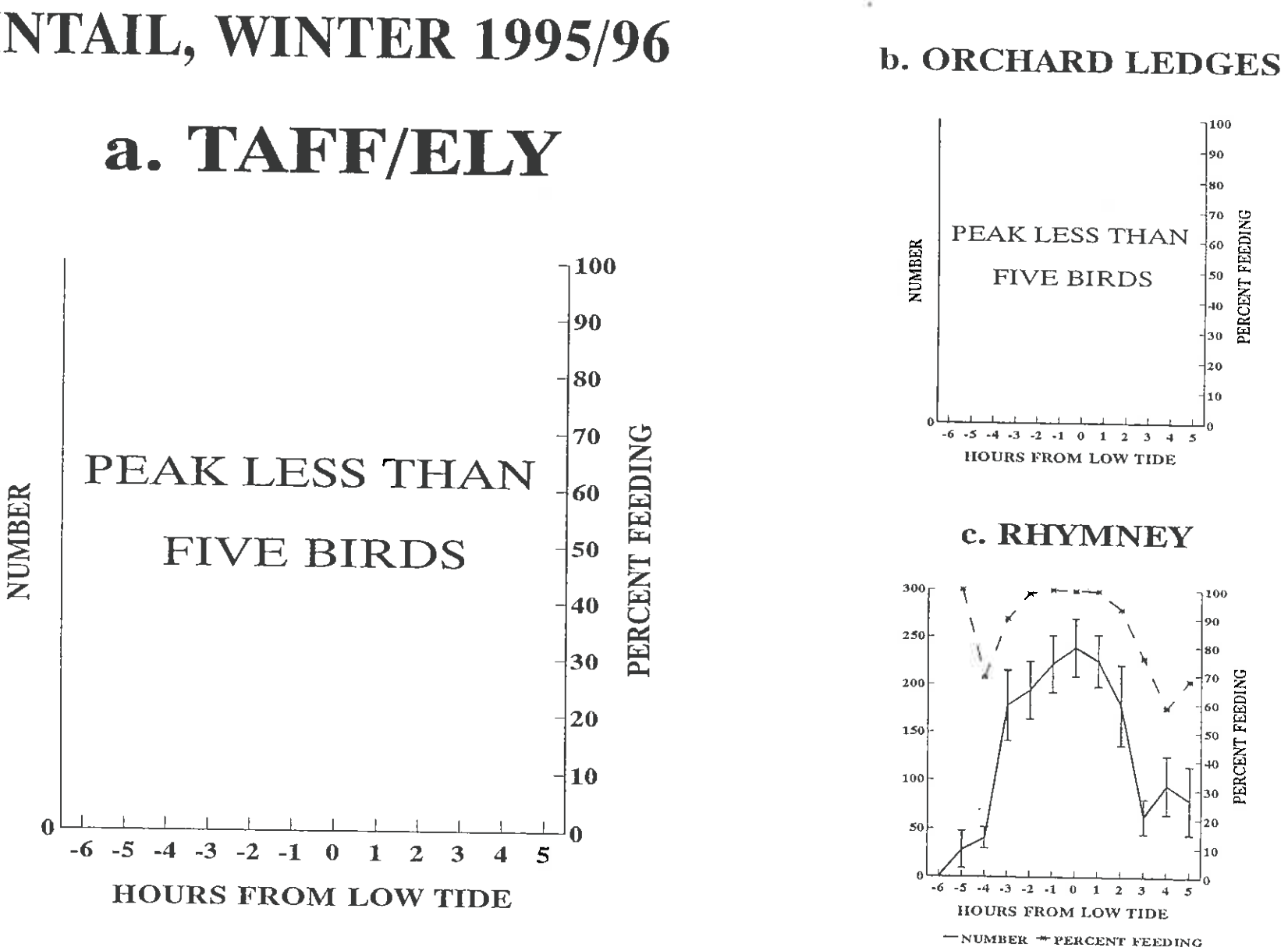


Figure 3.5.3.3 The total number of Pintail present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

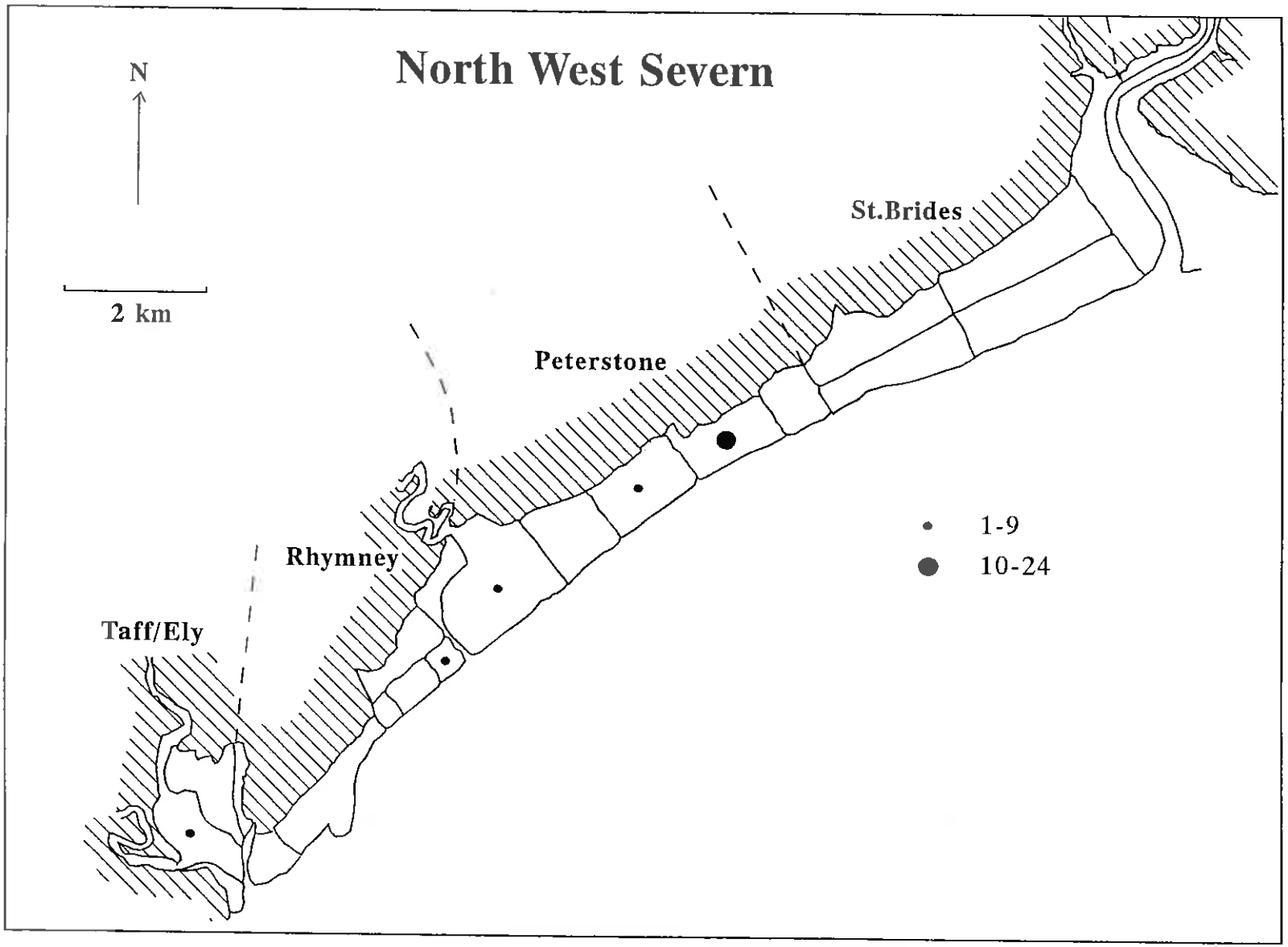


Figure 3.5.4.1 The low tide distribution of feeding Pochard on the northwest Severn during winter 1995/96.

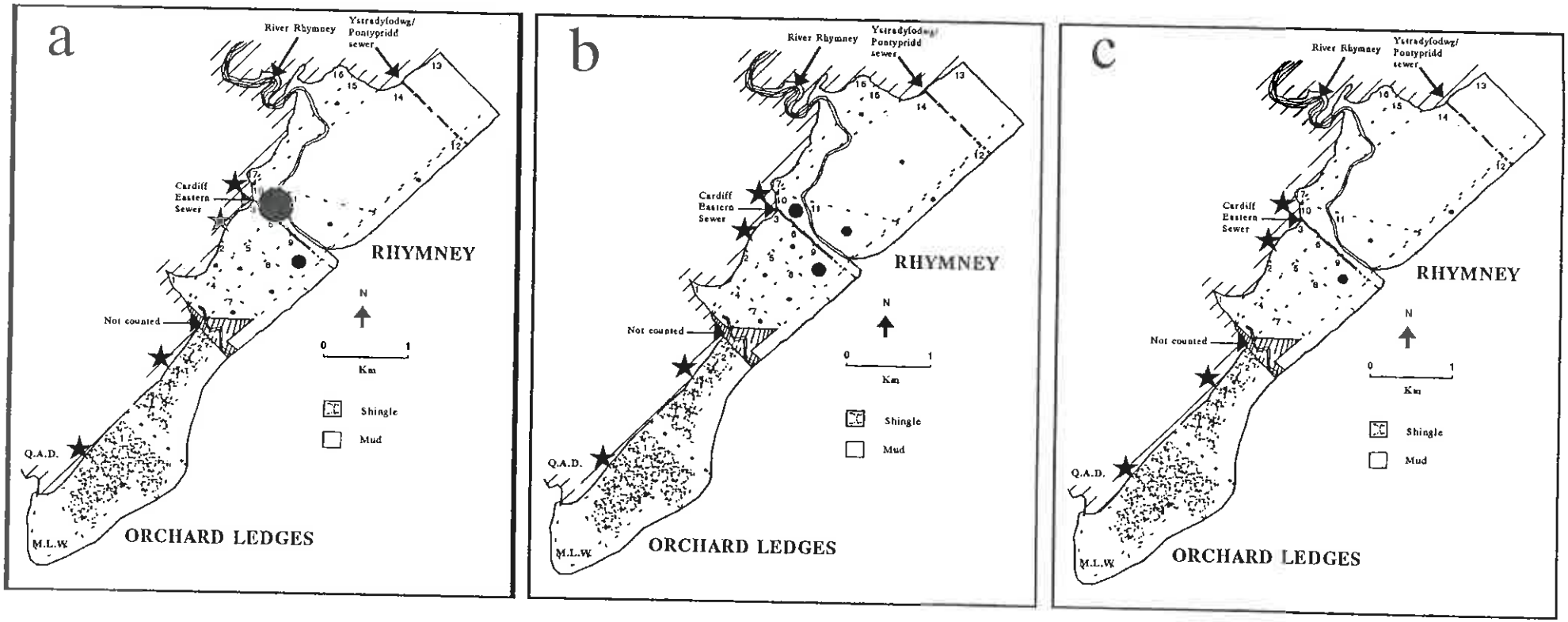


Figure 3.5.4.2
The distribution of feeding Pochard on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-9	•	50-99	●
10-24	•	100-199	●
25-49	●	>200	●

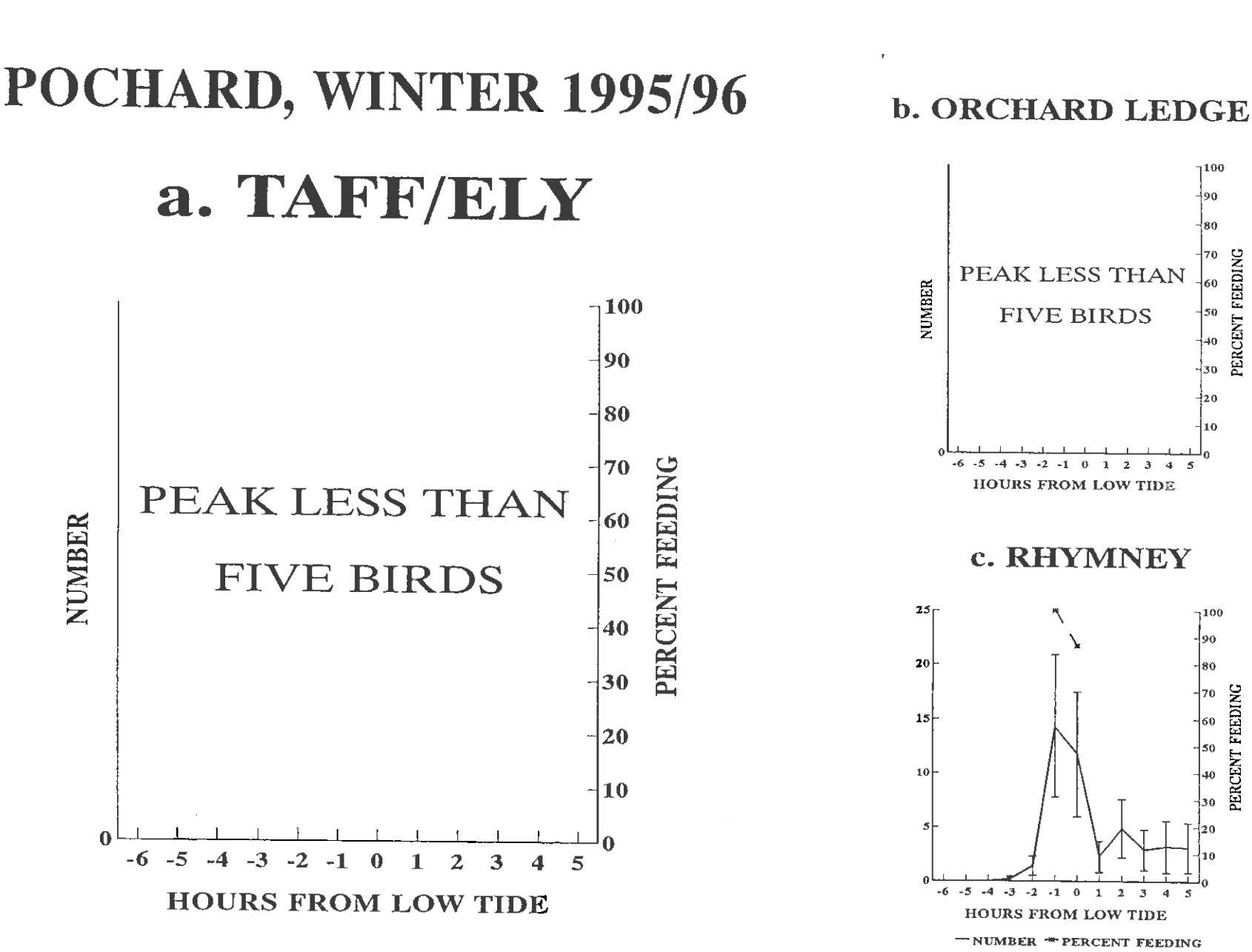


Figure 3.5.4.3 The total number of Pochard present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

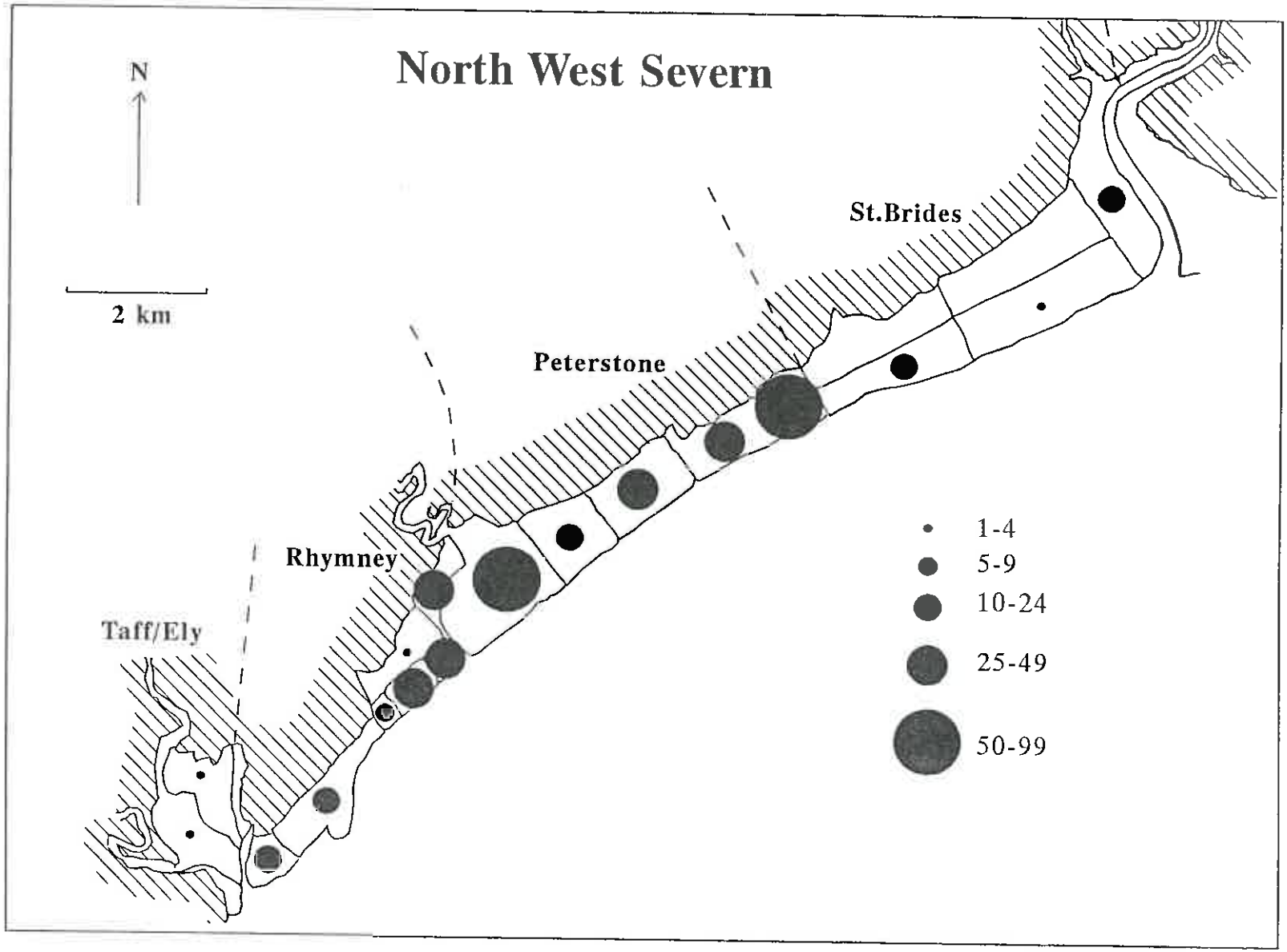


Figure 3.5.5.1 The low tide distribution of feeding Oystercatcher on the northwest Severn during winter 1995/96.

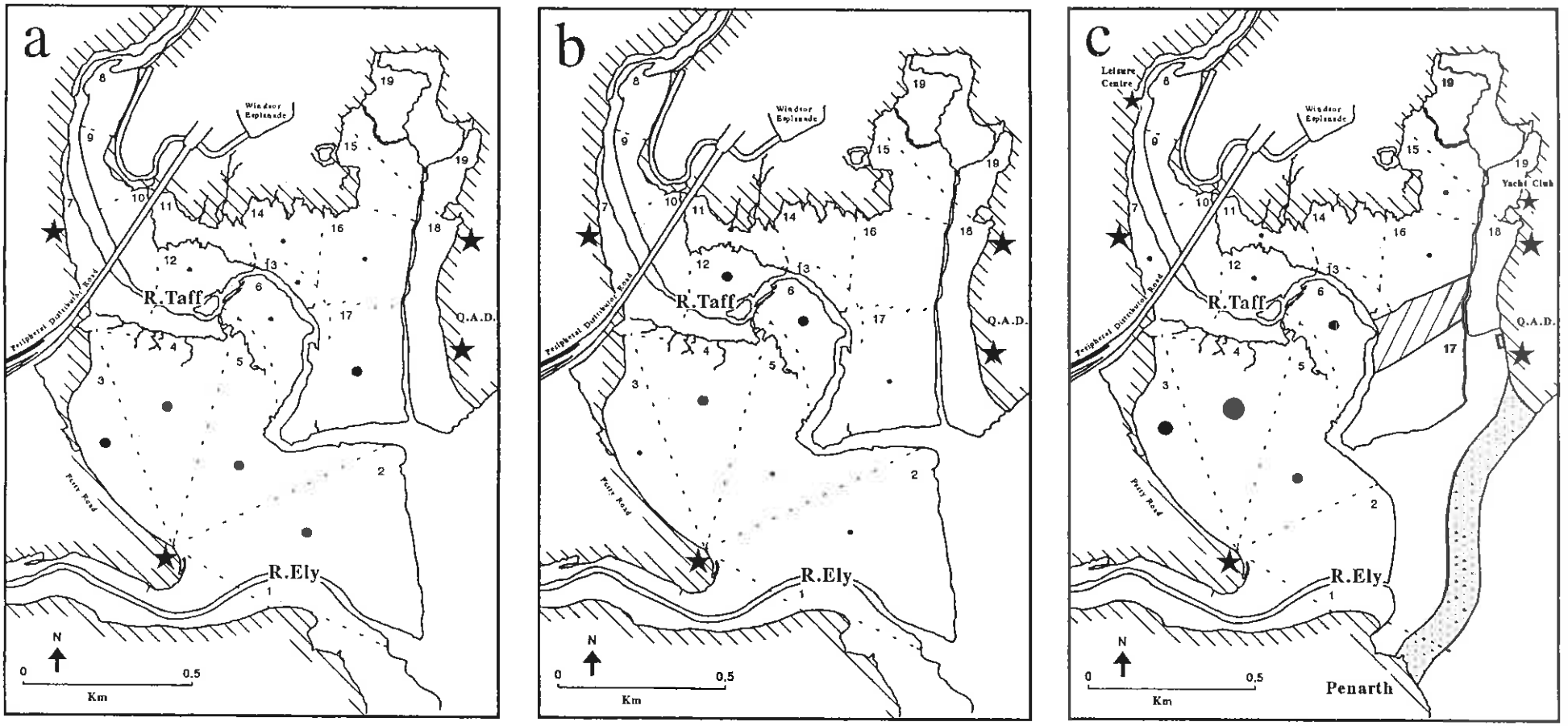


Figure 3.5.5.2
The distribution of feeding Oystercatcher on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-9	·	50-99	●
10-24	•	100-199	●
25-49	●	>200	●

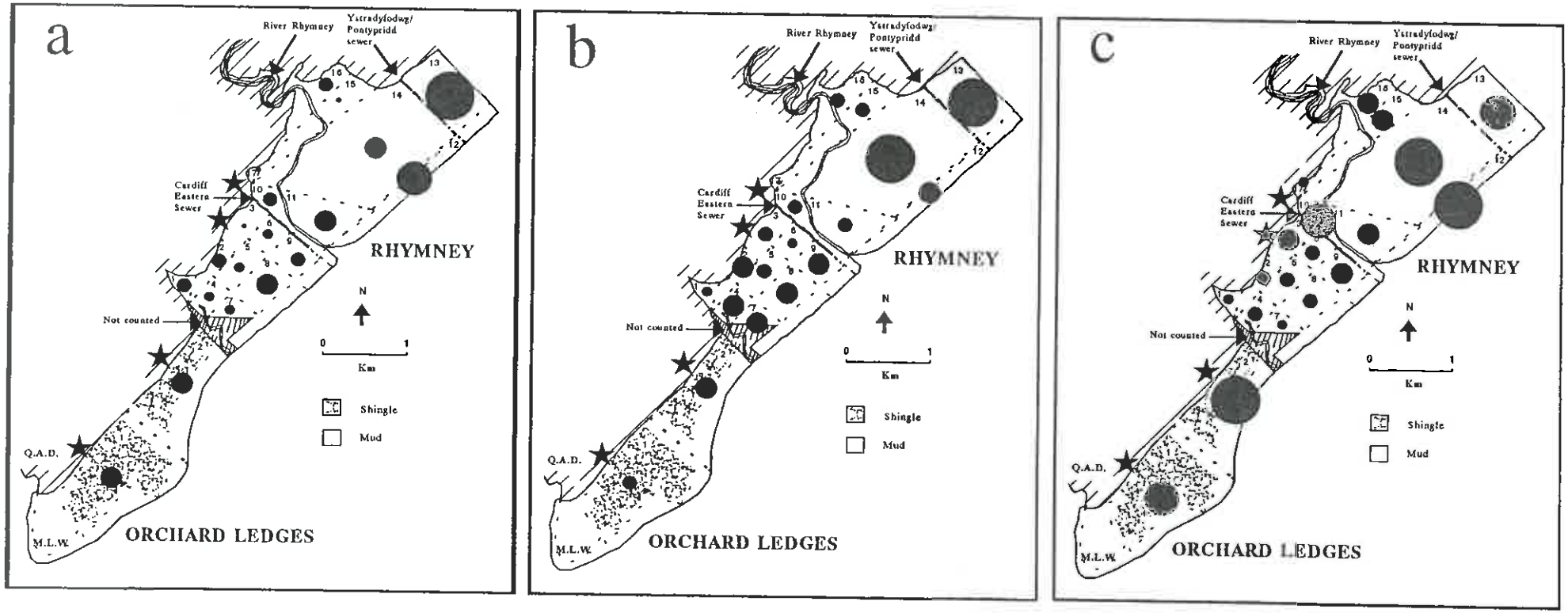


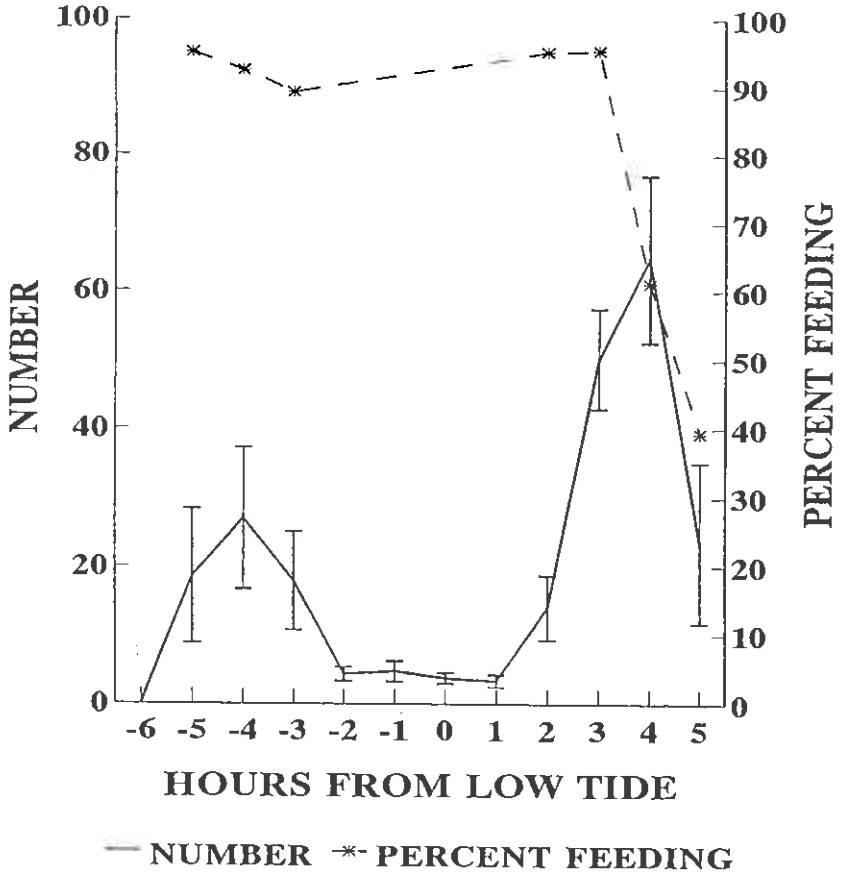
Figure 3.5.5.3
The distribution of feeding Oystercatcher on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

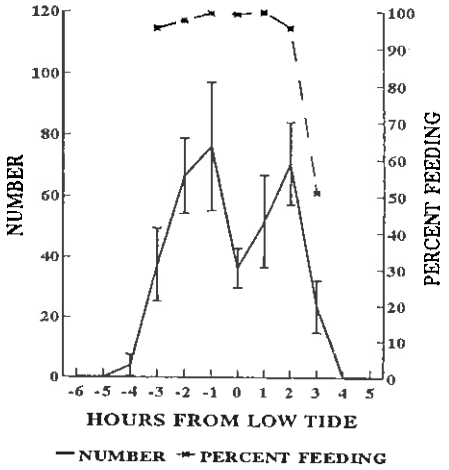
1-9	·	50-99	●
10-24	•	100-199	●
25-49	●	>200	●

OYSTERCATCHER, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

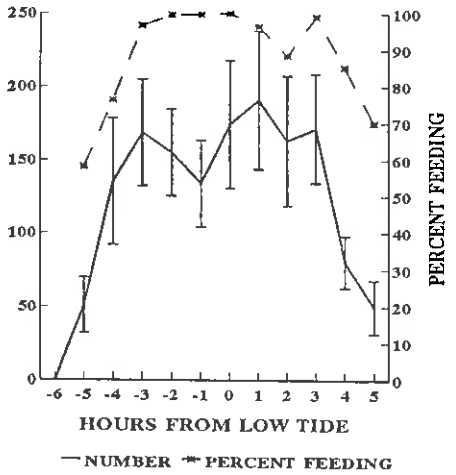


Figure 3.5.5.4 The total number of Oystercatcher present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

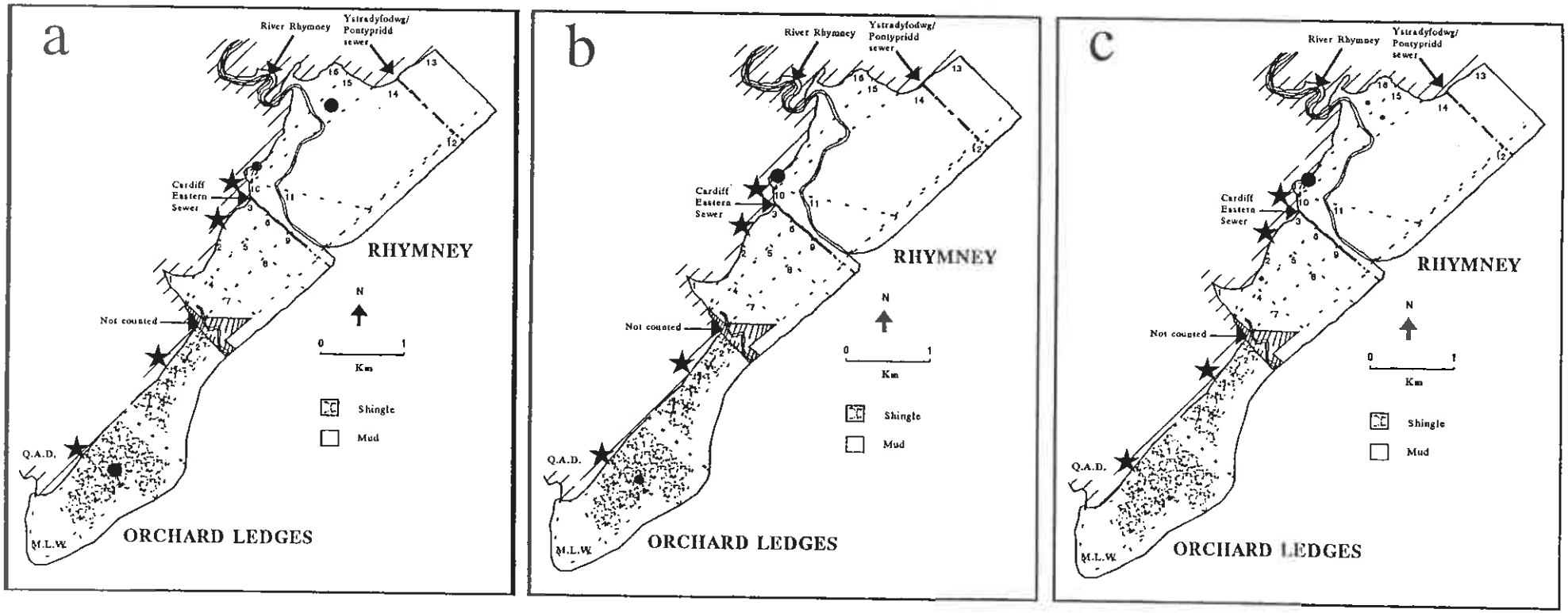


Figure 3.5.6.1
The distribution of feeding Ringed Plover on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	·	25-49	●
5-9	•	50-99	●
10-24	•	>100	●

RINGED PLOVER, WINTER 1995/96

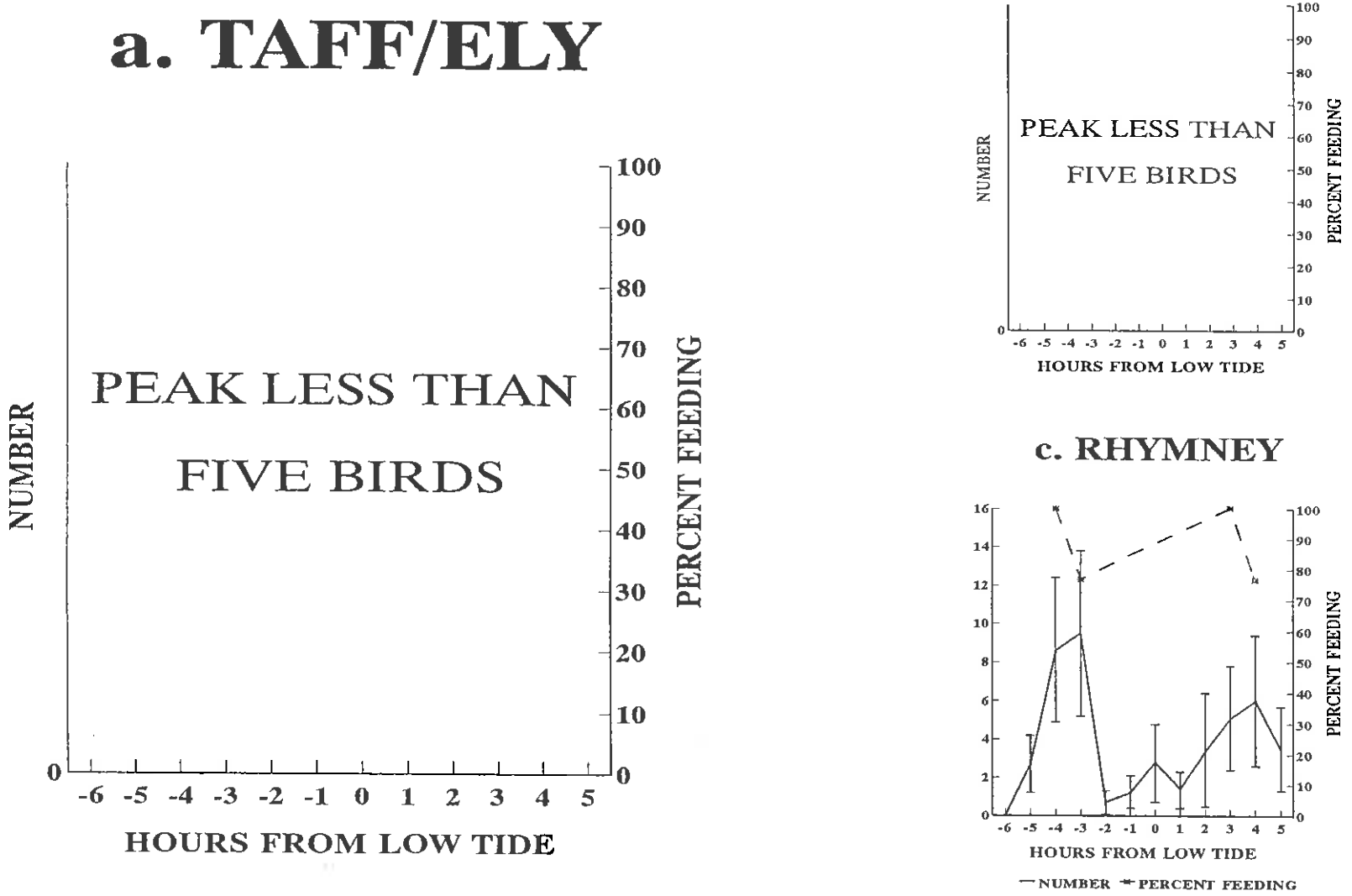


Figure 3.5.6.2 The total number of Ringed Plover present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

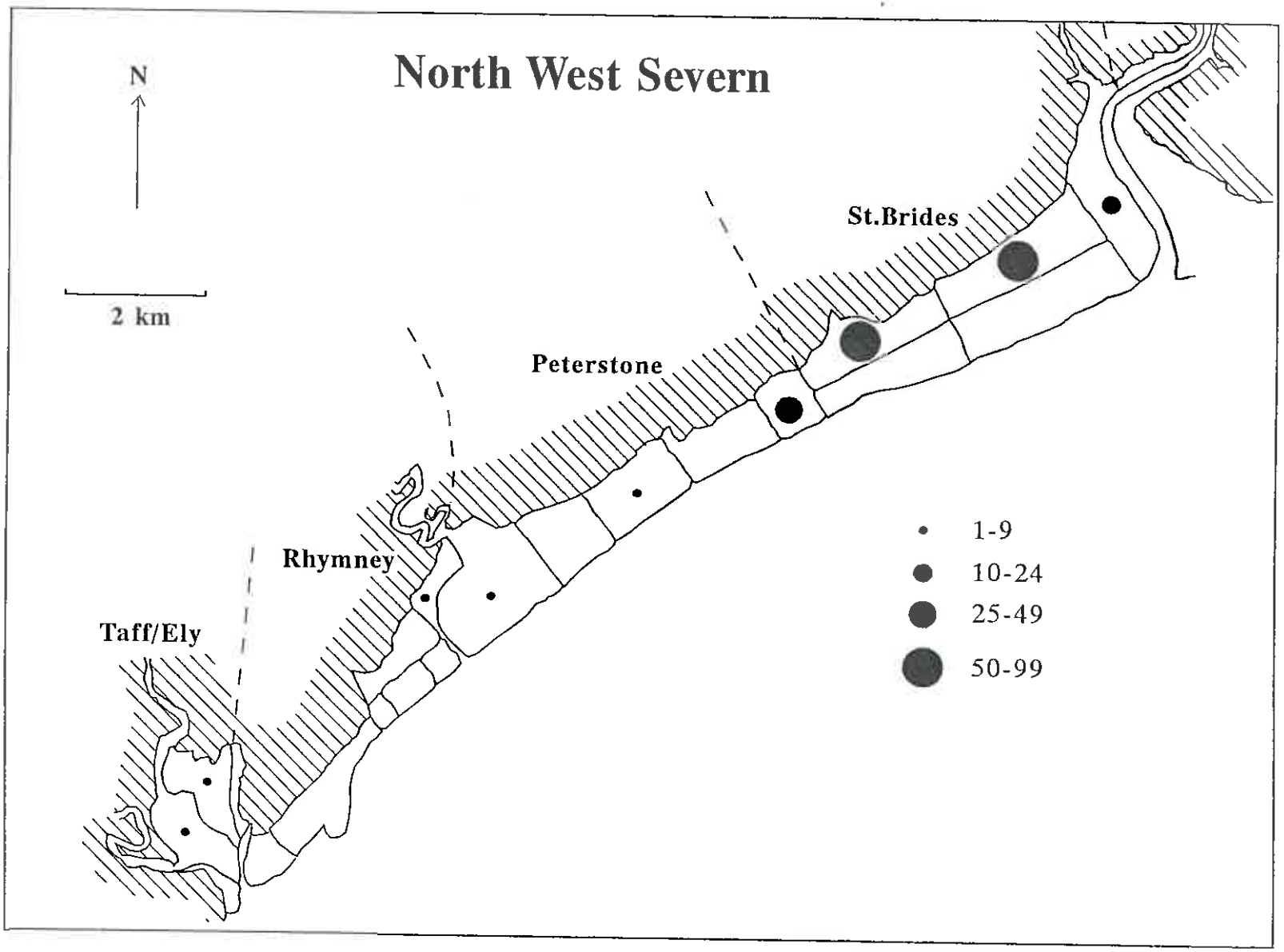


Figure 3.5.7.1 The low tide distribution of feeding Grey Plover on the northwest Severn during winter 1995/96.

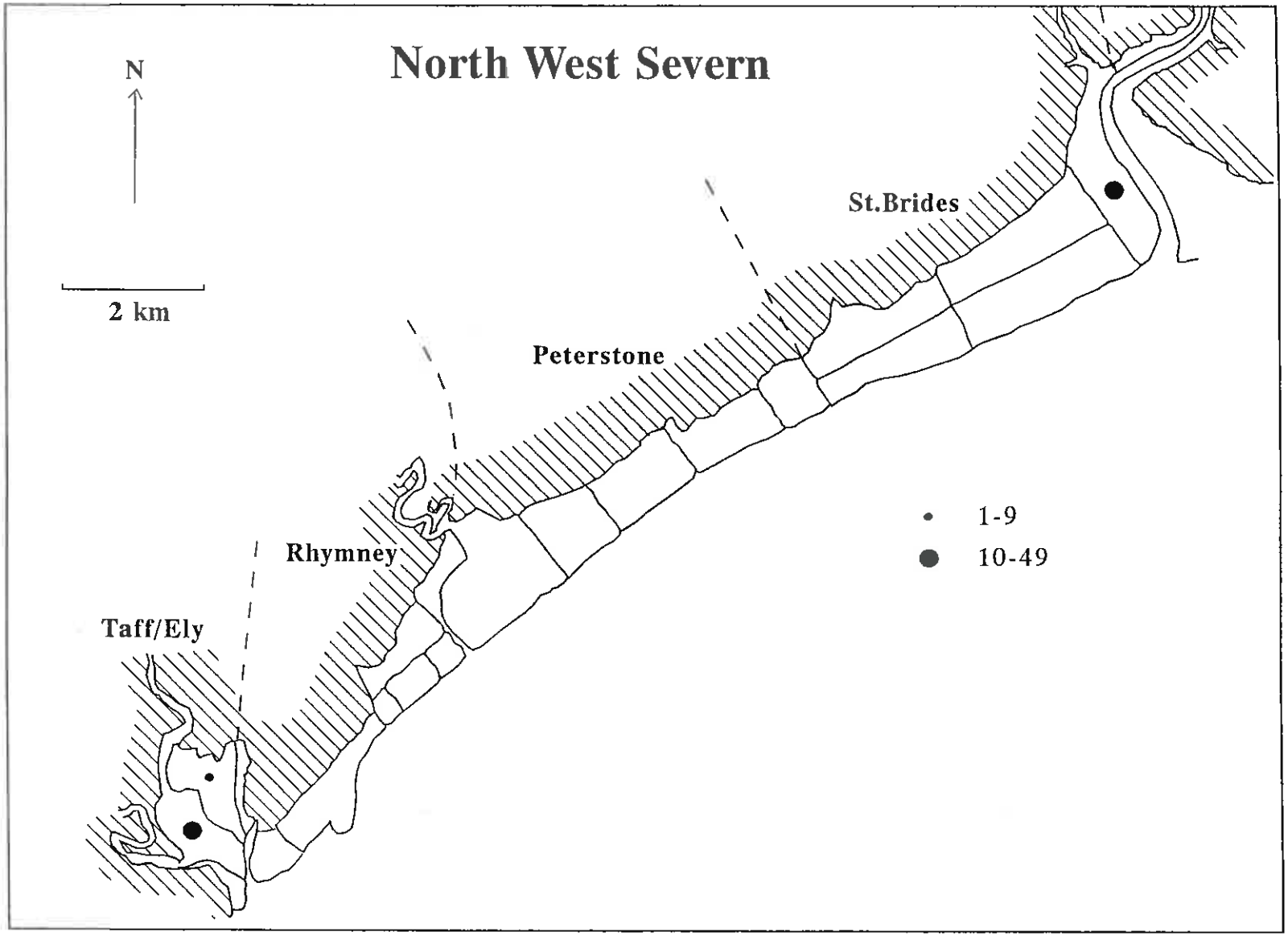


Figure 3.5.8.1 The low tide distribution of feeding Lapwing on the northwest Severn during winter 1995/96.

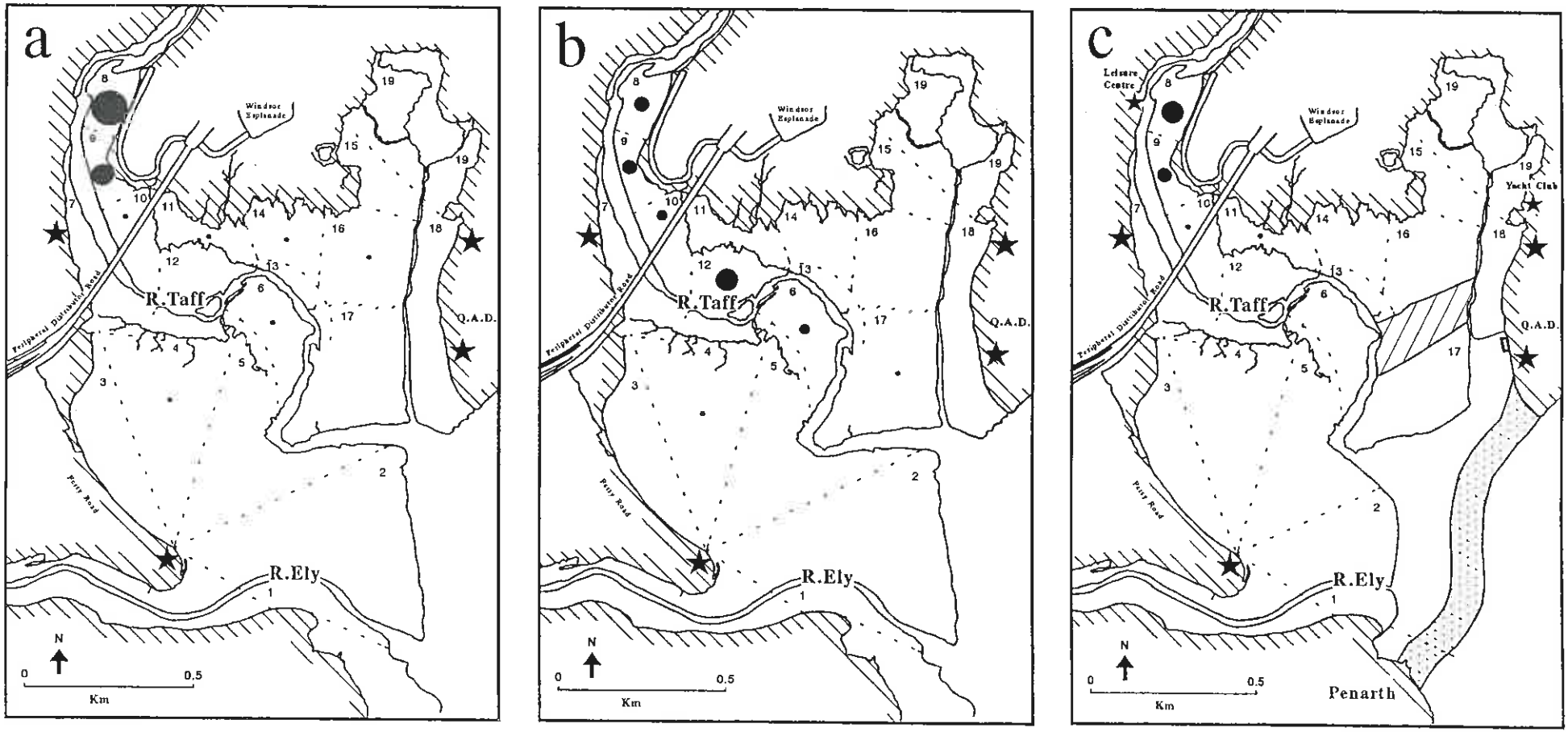


Figure 3.5.8.2
The distribution of feeding Lapwing on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	·	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

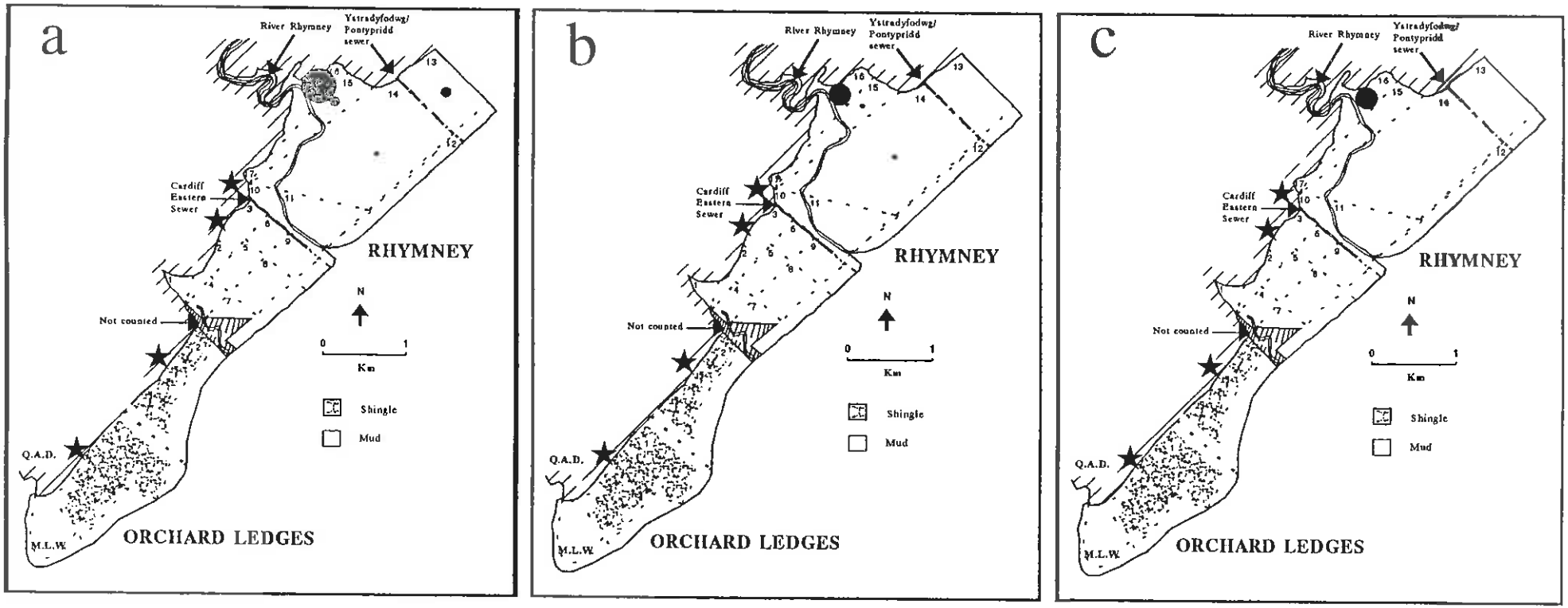


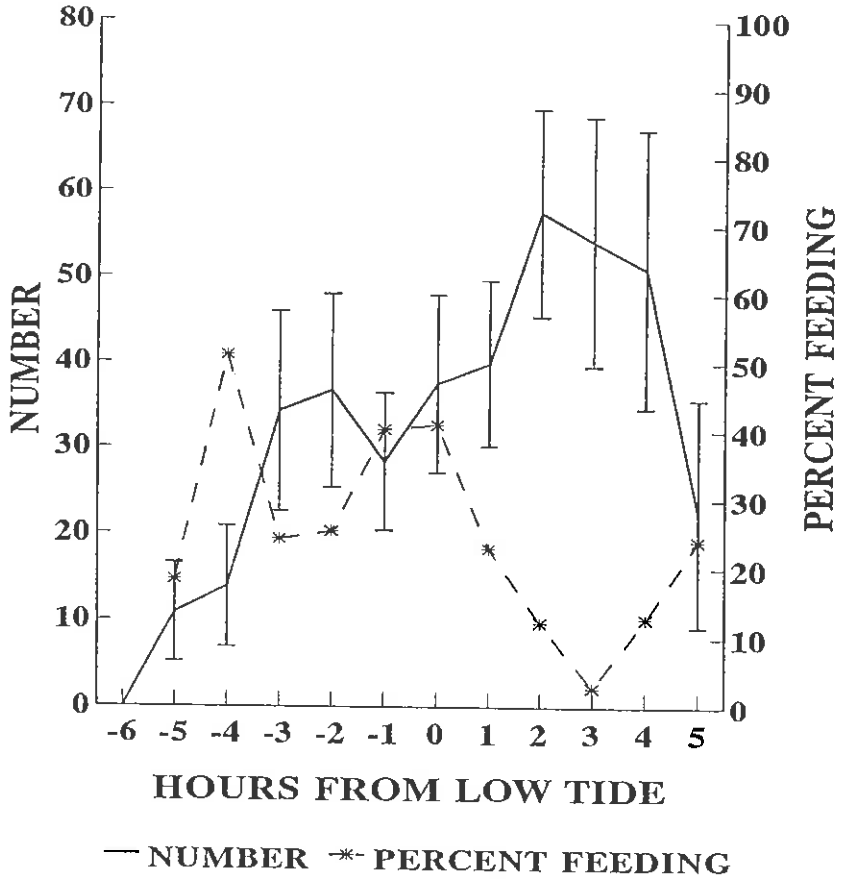
Figure 3.5.8.3
The distribution of feeding Lapwing on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

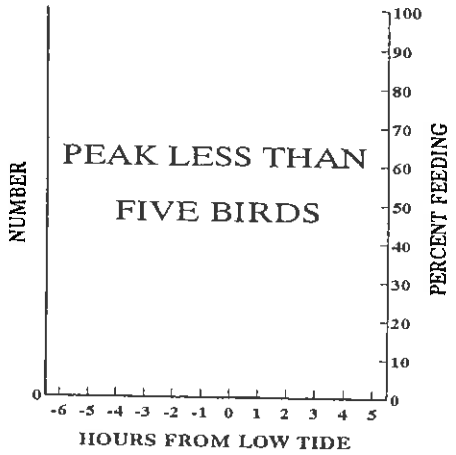
1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

LAPWING, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

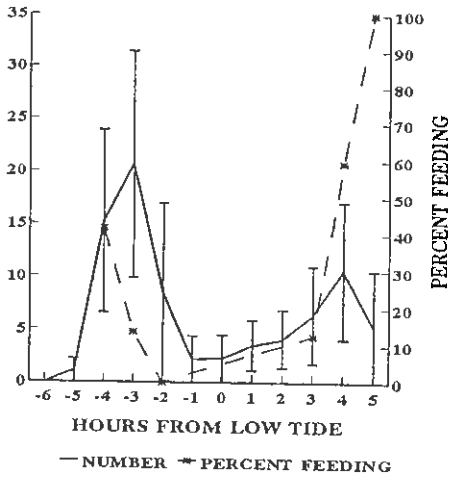


Figure 3.5.8.4 The total number of Lapwing present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

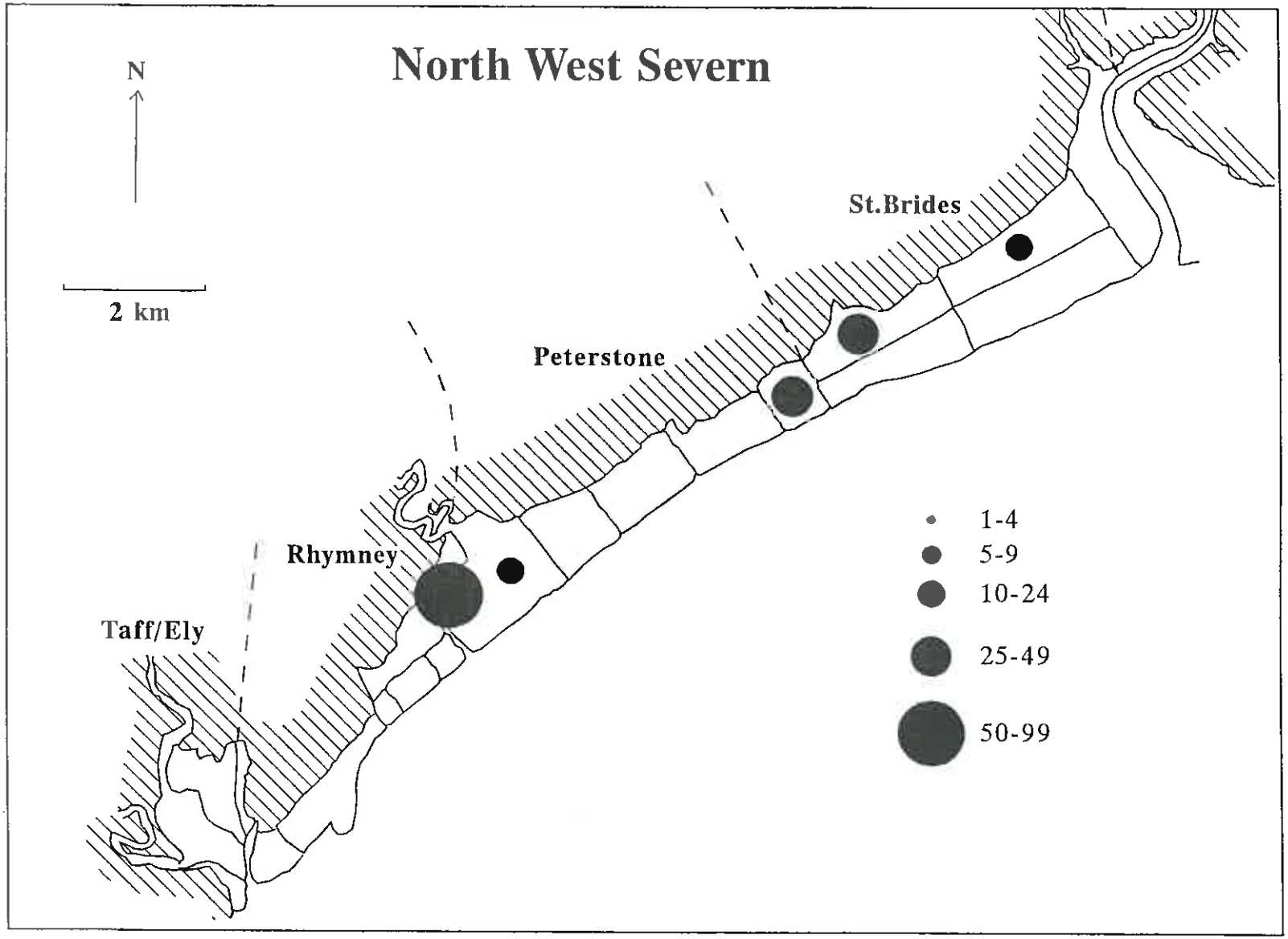


Figure 3.5.9.1 The low tide distribution of feeding Knot on the northwest Severn during winter 1995/96.

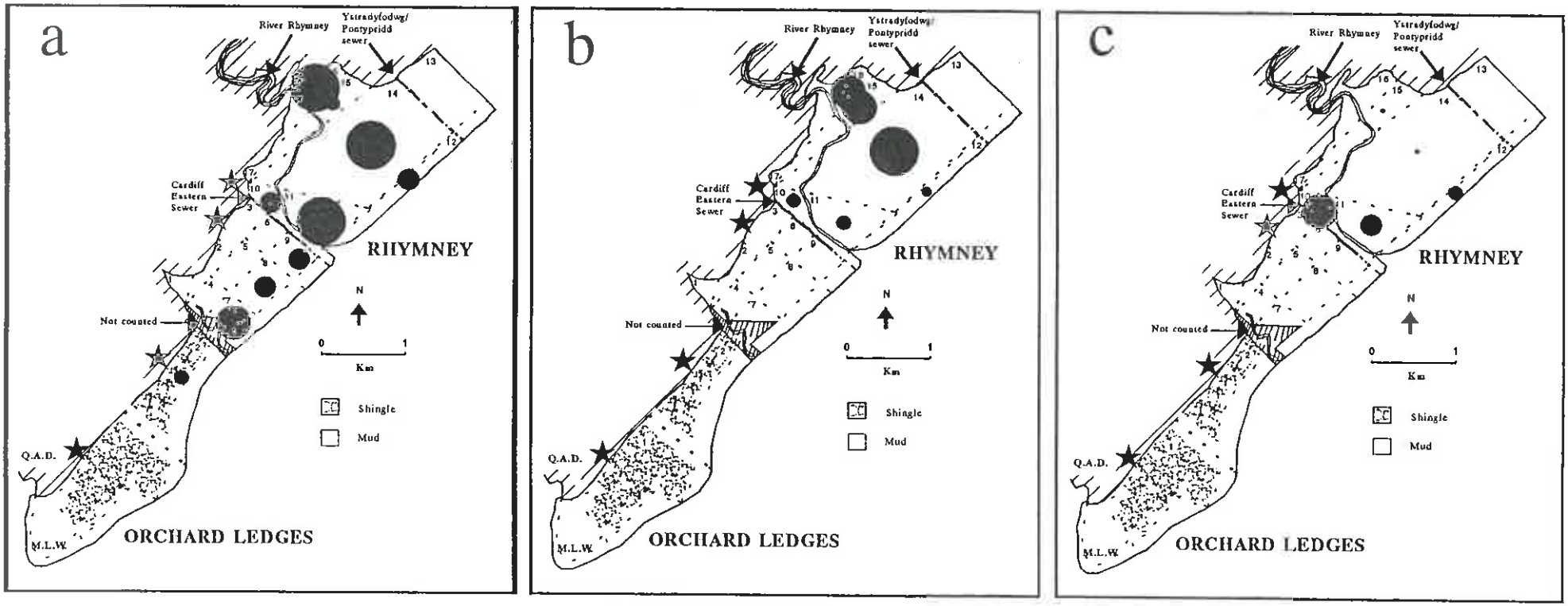


Figure 3.5.9.2
The distribution of feeding Knot on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

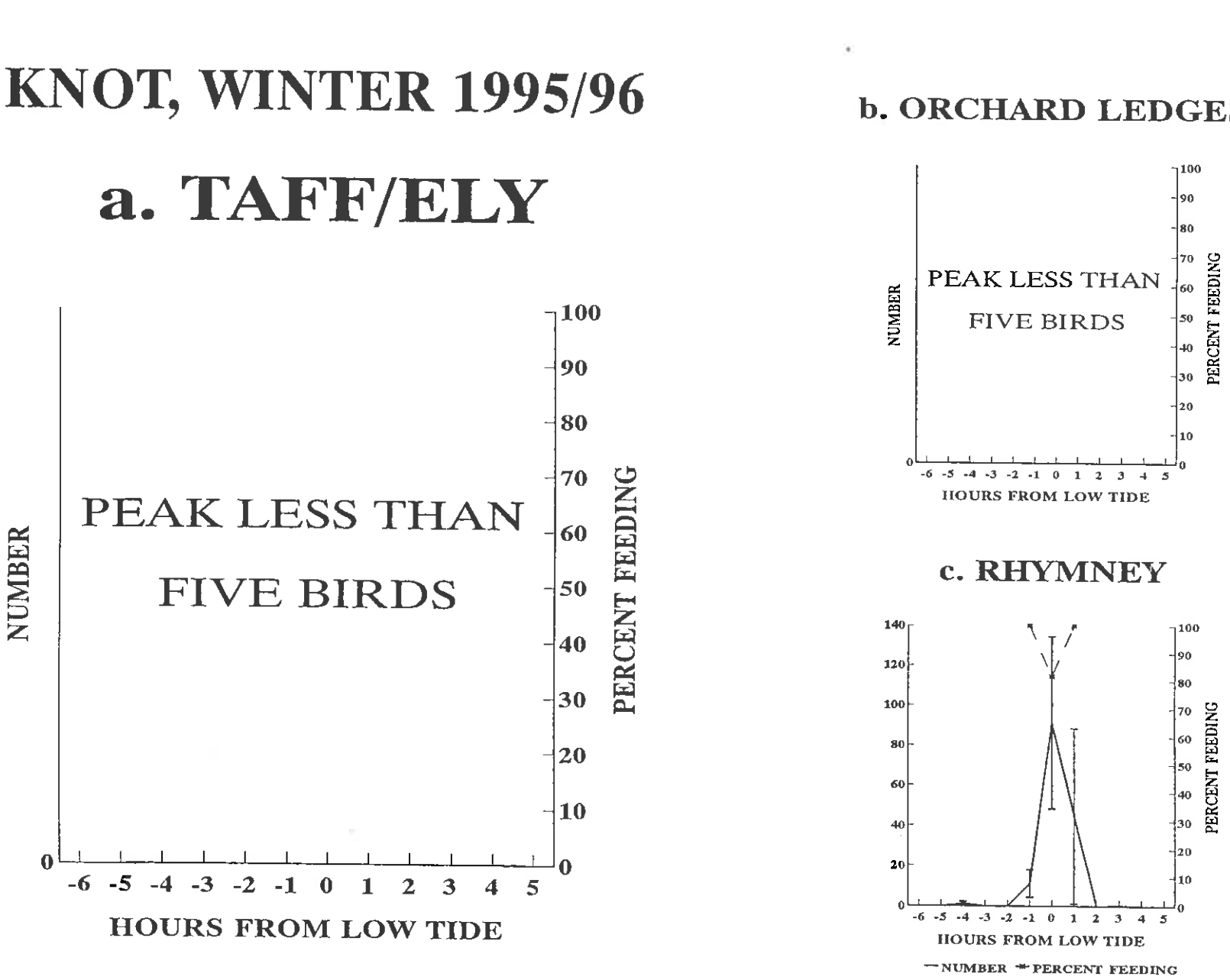


Figure 3.5.9.3 The total number of Knot present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

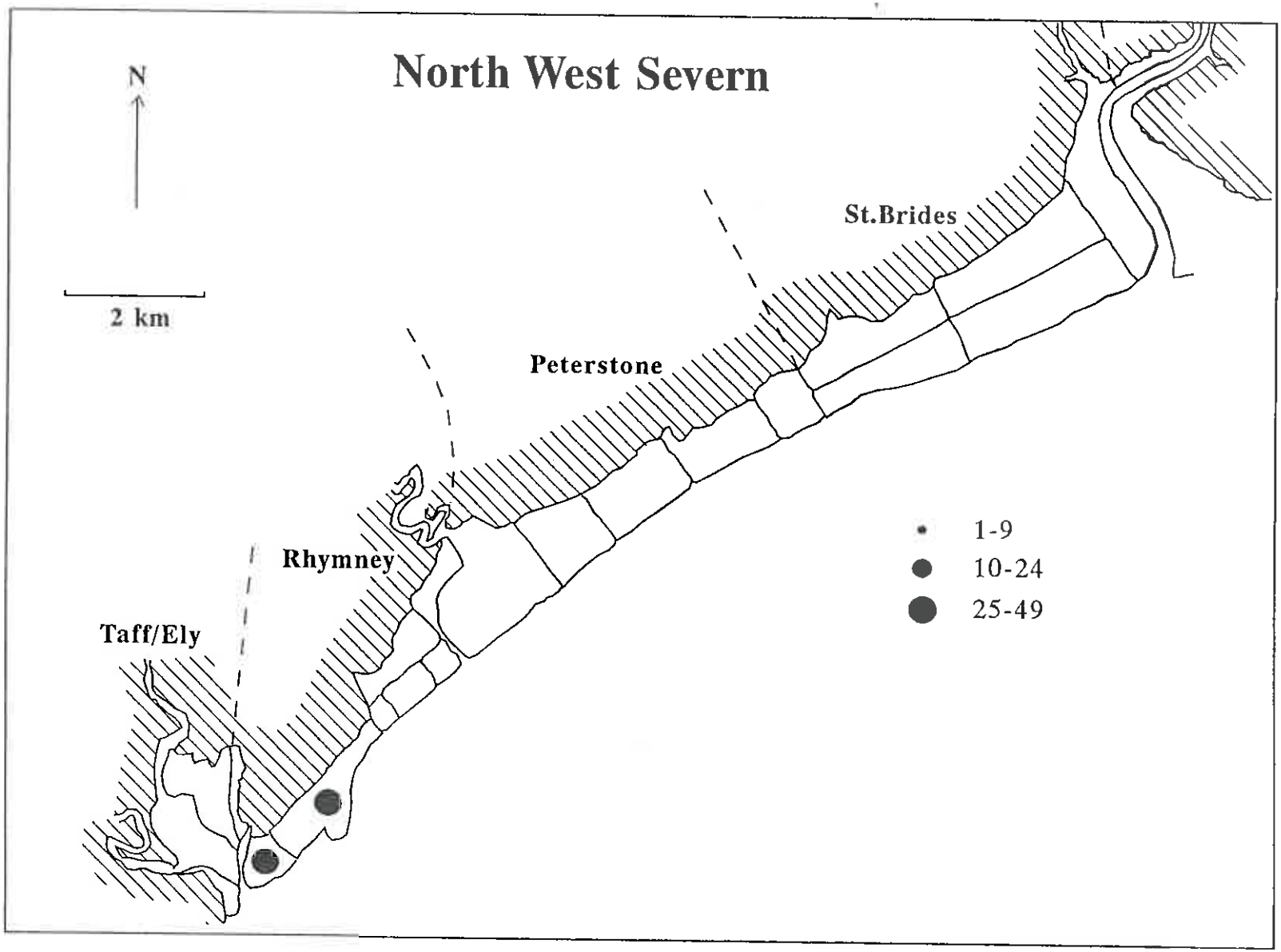


Figure 3.5.10.1 The low tide distribution of feeding Turnstone on the northwest Severn during winter 1995/96.

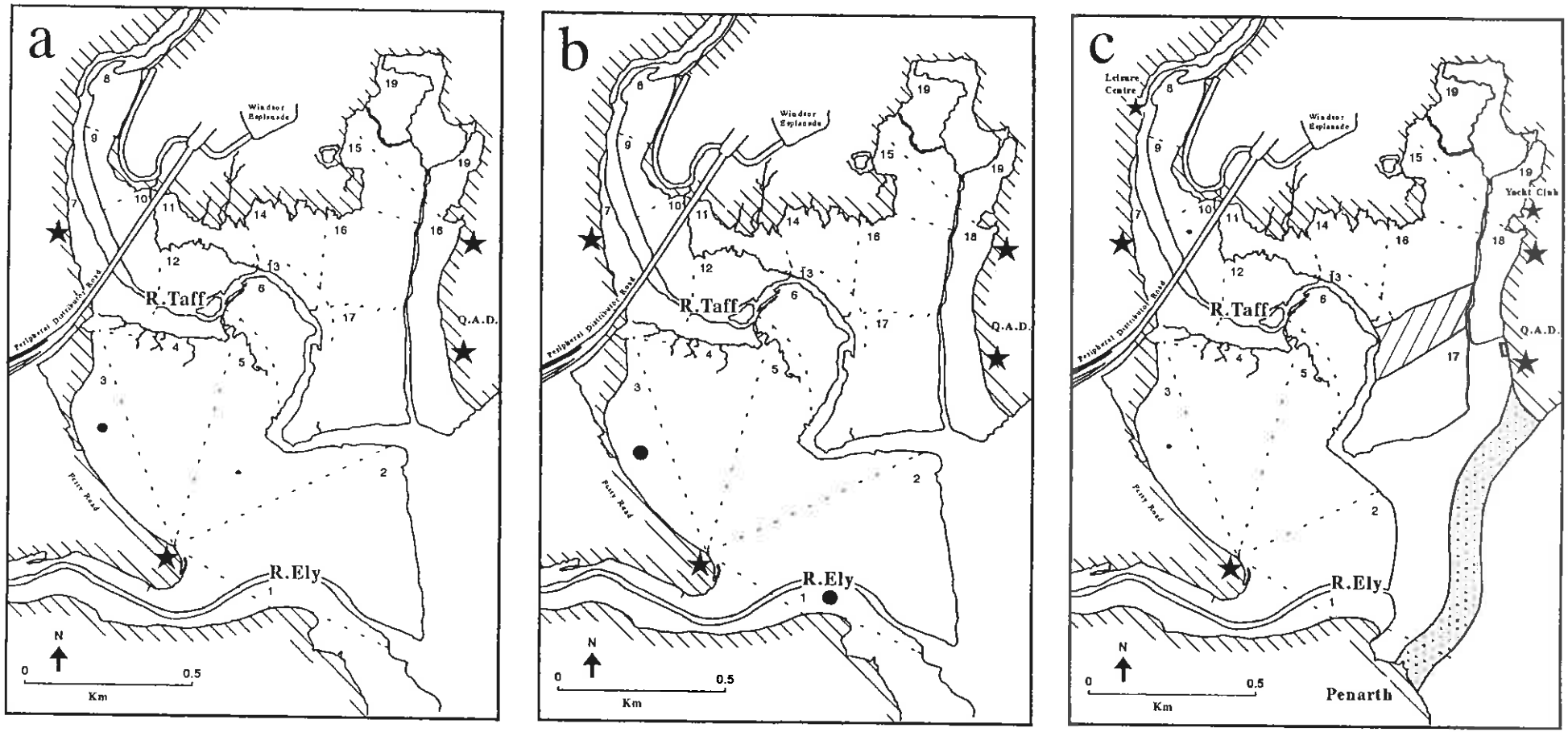


Figure 3.5.10.2
The distribution of feeding Turnstone on the Taff/Ely all day site during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

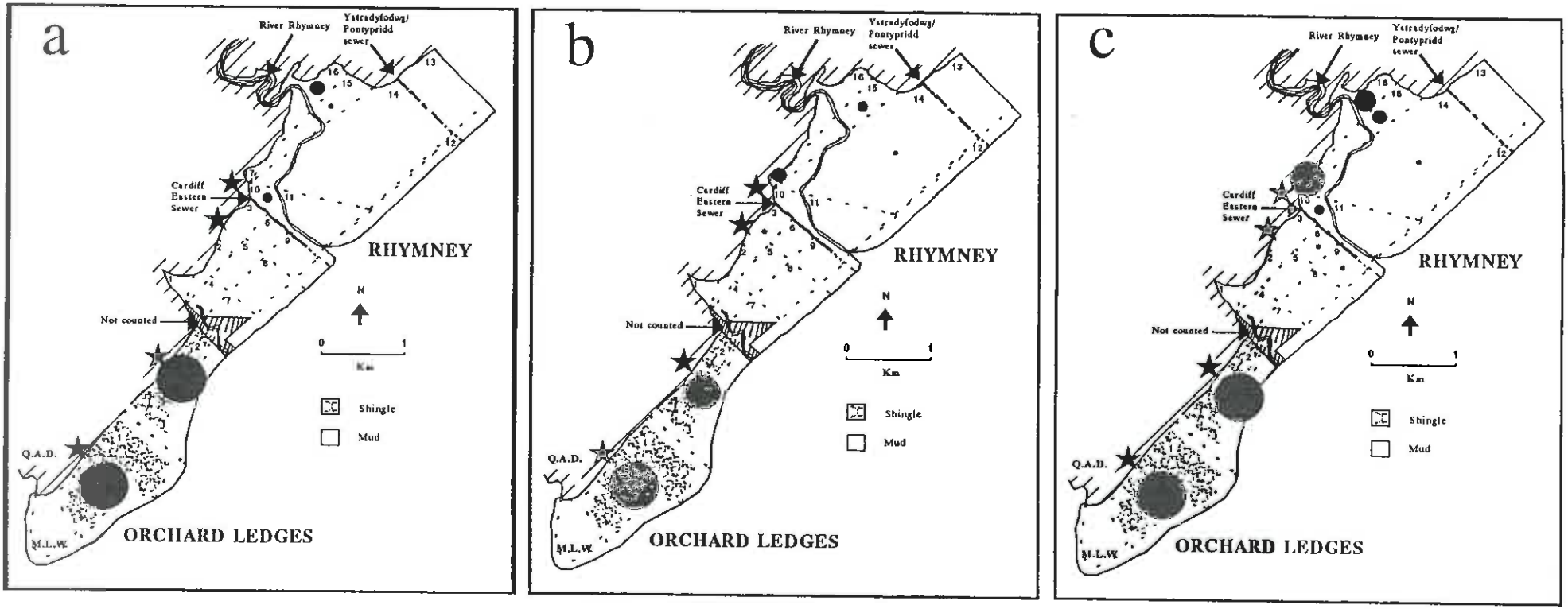


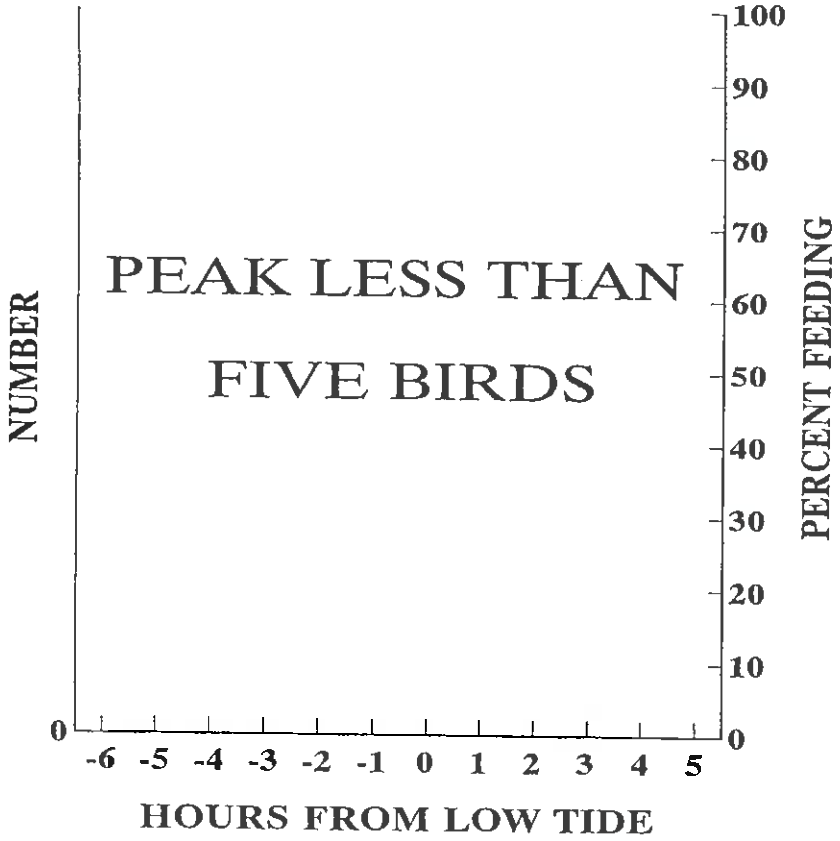
Figure 3.5.10.3
The distribution of feeding Turnstone on the Rhymney and Orchard Ledges all day sites during winter. The average number of bird hours per tidal cycle is depicted.
a = 1993/94; b = 1994/95; c = 1995/96.

Key

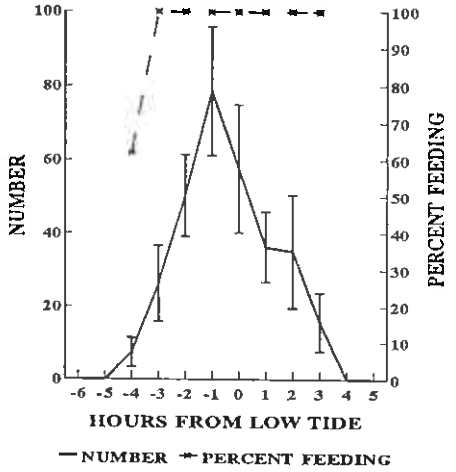
1-4	•	25-49	●
5-9	•	50-99	●
10-24	●	>100	●

TURNSTONE, WINTER 1995/96

a. TAFF/ELY



b. ORCHARD LEDGES



c. RHYMNEY

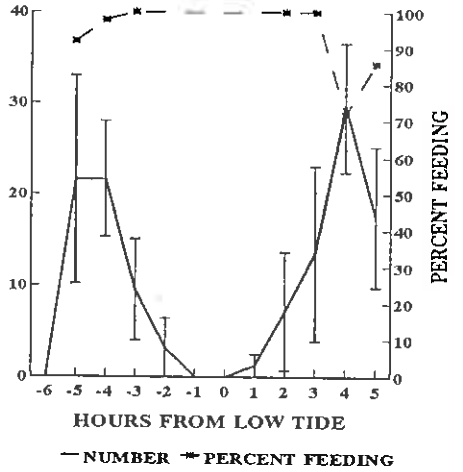


Figure 3.5.10.4 The total number of Turnstone present and the percentage feeding during each hour of the tidal cycle at each of the three all day study sites during winter 1995/96.

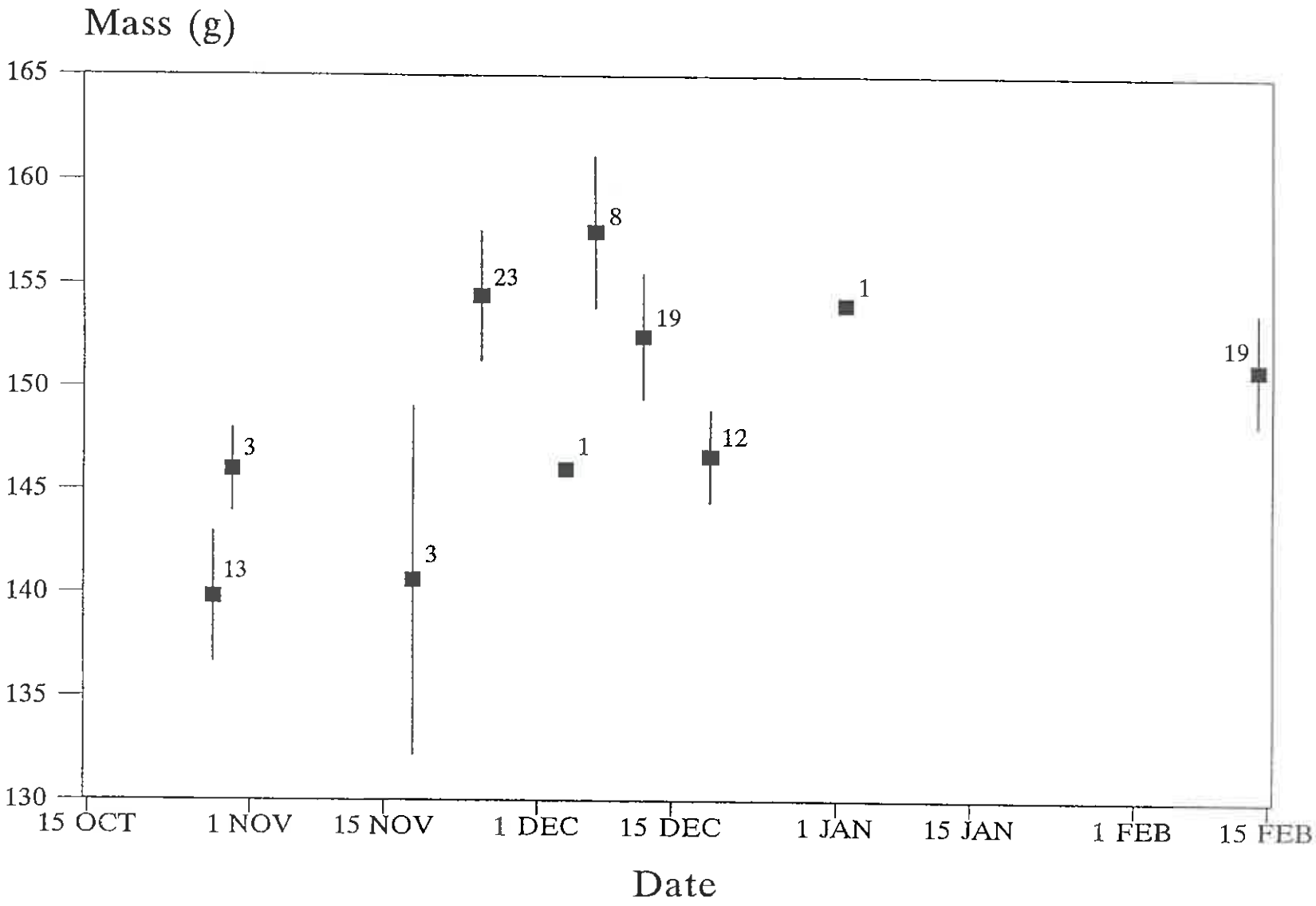


Figure 7.3.1 The masses of adult Redshank caught at Cardiff Bay and at Rhymney over winter 1995/96. Data are shown with sample sizes and standard error bars.