Time budgets of Northern Pintails wintering in the Sacramento Valley, California

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Introduction

Analysis of time budgets should improve our understanding of habitat utilization and niche separation among species (Titman 1981), and aid the management of hunted species (Raveling *et al.* 1972).

Northern Pintail *Anas acuta* are the most abundant ducks in California during fall and winter and are heavily exploited during the hunting season; however, time budget data are available only from Louisiana (Tamisier 1976) and Senegal (Roux *et al.* 1978). Heitmeyer and Fredrickson (1981) showed that breeding success of Mallard *A. platyrhynchos* may be a function of the extent of wetlands during winter, thus behaviour should vary with markedly different habitat conditions. Therefore, Pintail time budgets (diurnal) were quantified from August through March in California both during a winter of high rainfall with abundant wetland habitat, and a winter of low rainfall with restricted habitat. In addition, activities were compared through the season and day, relative to sex, habitat, flock size, wind velocity, and with previous studies to examine geographic variation.

Study area (Figure 1)

California's Central Valley supports about 60% of the waterfowl of the Pacific Flyway during winter; the Valley's ecological and geographical features were described by Gilmer *et al.* 1982. I conducted field work in the Sacramento Valley on Sacramento, Delevan, and Colusa National Wildlife

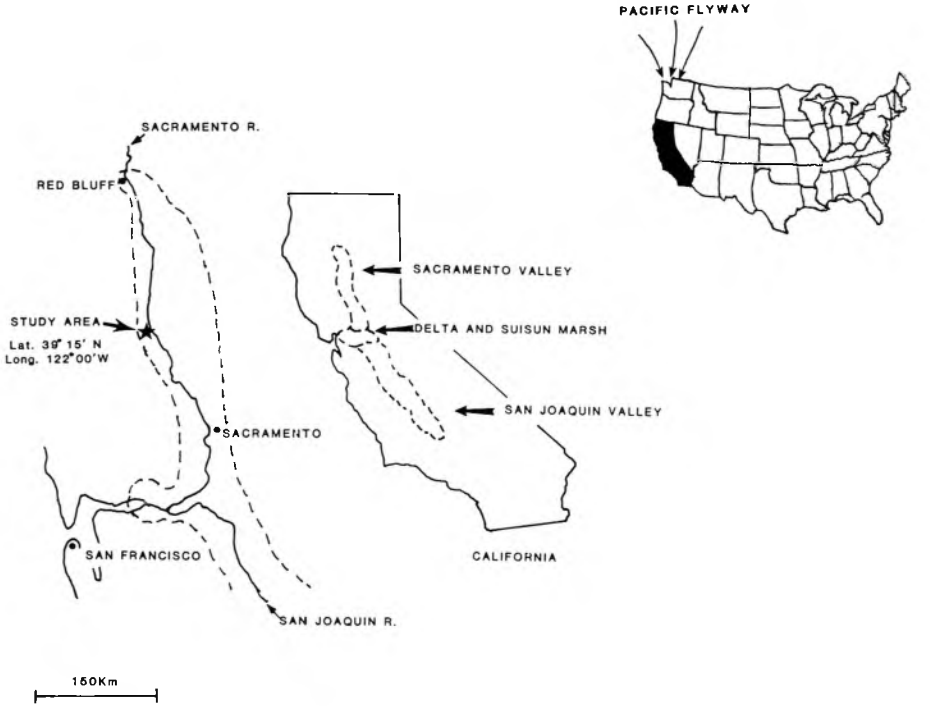

Figure 1. Sacramento Valley study area.

Refuges (N.W.R.) in Glenn and Colusa counties about 130 km north of Sacramento. These three refuges encompass 8,275 ha of uplands and marshes. *Scirpus*, *Typha*, *Potamogeton*, *Polygonum*, *Echinochloa*, *Leptochloa*, *Paspalum*, and *Cyperus* dominated summer-irrigated and permanently wet sites, while *Heleochloa*, *Grindelia*, *Psilocarphus*, *Cynodon*, and *Rumex* were common on drier areas. Rice *Oryza sativa* was grown on each refuge to attract ducks away from commercial rice (nearly 243,000 ha). Thousands of hectares of harvested rice fields, many flooded for shooting, and several thousand hectares of privately owned marshes provided important feeding areas for waterfowl.

Rainfall during winter 1980–81 was 54% of average from August through February ($\bar{x}$ = 34.5 cm), but was 148% of average in 1981–82 as measured at Sacramento (NOAA 1980–82). During the wet year, flooded areas supplemented traditional habitat. Leveed floodways were inundated, rice seed was extensively available to birds in harvested fields partially flooded, and rainwater accumulated in vast areas of pastures and other uplands. During the dry winter, little additional habitat was available except during January's normal rainfall. Fall ploughing of harvested rice fields eliminated many feeding areas and ducks concentrated on refuge roosts during the day.

Methods

Pintail flocks were observed during daylight from August through March 1980–82 on two to four days per month, within the second to last week, except that no data were collected in November 1980. Observations were made where Pintail flocks were found, not at random or pre-selected sites. Daylight hours (sunrise to sunset) were sampled within five equal "day-intervals" (sunrise, midmorning, midday, afternoon, evening) ranging in length from 2 hours 45 minutes (August) to 1 hour 50 minutes (December). Predawn (one-half hour before sunrise to sunrise) and sunset (sunset to one-half hour after sunset) intervals were also sampled. Data were collected during three, 3-minute sampling periods for each sex during each of the seven intervals (predawn was not sampled in 1980–81). Line of sight in the middle of field of view of a spotting telescope (25-40X) was considered a "transect" across the flock (Miller 1983); random transects were run continuously during each 3-minute sample. The behaviour of each duck encountered along the transect was recorded as loaf (sleep, rest), feed, court (aerial, terrestrial, or aquatic social display), preen (feather maintenance, wing stretch, body shake), locomote (walk, swim), fly (not associated with courtship), drink, aggression, alert, bathe, copulate (copulation, and pre- and post-copulatory behaviour), and dive (not associated with feeding). This instantaneous flock or scan sample (Altmann 1974) allowed me to estimate the percentage of day allocated to each behaviour (Tamisier 1976).

Supplementary data were collected on habitat (marsh or rice), flock size, and wind speed for each sample period. Activity data by sex were not collected in August or September because of difficulties in determining age-sex classes. Sex differentiation was achieved in October 1981, and the relevant percentages applied to October 1980 when it was not. Data during 80 hours (18 min/day-interval) of field observation were collected during the two years, including 96 day-intervals during 16 days in 1980–81, and 168 during 24 days in 1981–82.

Number of participating males and duration of courtship flights, and timing of feeding flights were recorded. Sex ratios were calculated by counting individuals in resting flocks each month. Refuge reports of ground counts were used to obtain population estimates.

Differences in time spent in activities among months and day-intervals, between sexes and years, and relative to flock size, wind speed, and habitat type were tested with chi-square analyses, the level of significance accepted being $p < 0.05$.

Results

Pintail populations

Pintail arrived in the Sacramento Valley the first week of August, and mean monthly populations on the three refuges were as high as 250,000 between September and January; peak populations exceeded 400,000. Pintails were the most common duck species, except in March when Northern Shoveler *Anas clypeata* and American Green-winged Teal *A. crecca*

carolinensis predominated.

Males made up 94% of the Pintail population in August. The proportion of females approximately doubled between August and September, and doubled again between September and October. The sex ratio approached parity (53% male) in January and remained unchanged thereafter.

Time-budget analyses

(i) Loafing

Loafing was the most frequently observed behaviour during most months (Figure 2), and during most day-intervals (Figure 3). Time allocated to loafing ranged from 2.5 hours/day in September to over 7 hours/day in February for males and females. Pintail loafed less in August, September, January, and March than other months, and more frequently in the dry than the wet winter (October, December, and February). Females consistently loafed more than males after October except in March 1982 (Figure 2). Pintail loafed more from midmorning through sunset than during predawn and dawn (Figure 3).

Pintails spent less time loafing when wind speeds exceeded 15 km/h (Figure 4). More time was spent loafing on marsh than rice during August, September, and February and March (Figure 5). Pintails spent less time loafing in flocks exceeding 10,000 ducks (Figure 6).

(ii) Feeding

Pintail fed most frequently from August through October, and during February (1982 only) and March (Figure 2). They spent an average of 6.6 hours/day feeding in August 1980 compared with 2.0 hours/day in August 1981, and allocated more time to feeding during January of the dry than wet winter. Time spent feeding was comparable to low midwinter levels in February of the dry winter, but was markedly higher in February 1982.

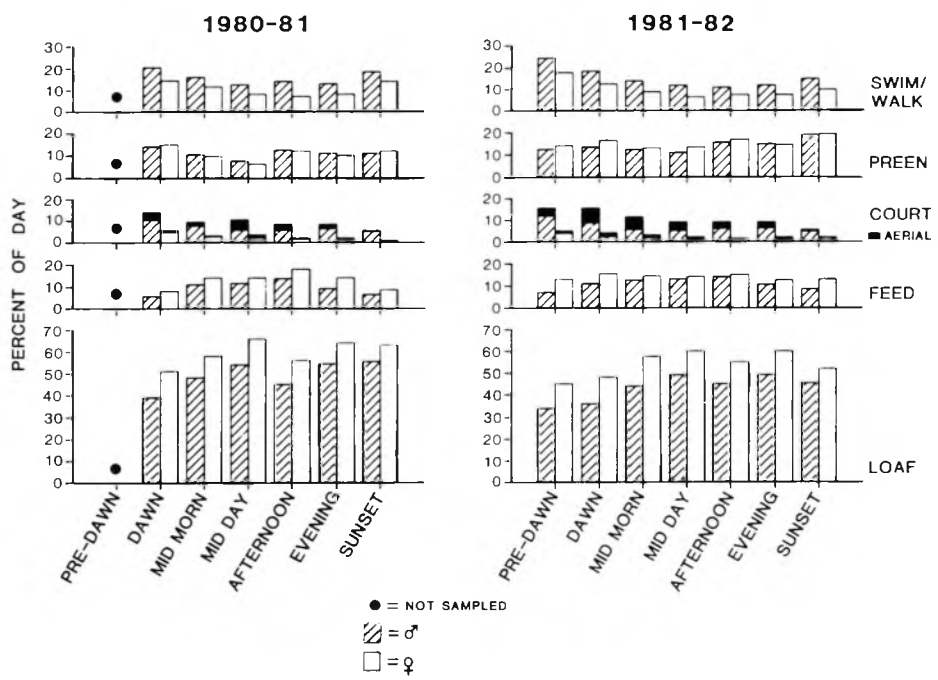

Figure 2. Proportion of the average day allocated to various activities by Northern Pintail during winter of 1980–81 (dry) and 1981–82 (wet). Data for day-intervals combined. Males and females not differentiated in August and September. Males and females estimated in October 1980. No data were collected November 1980.

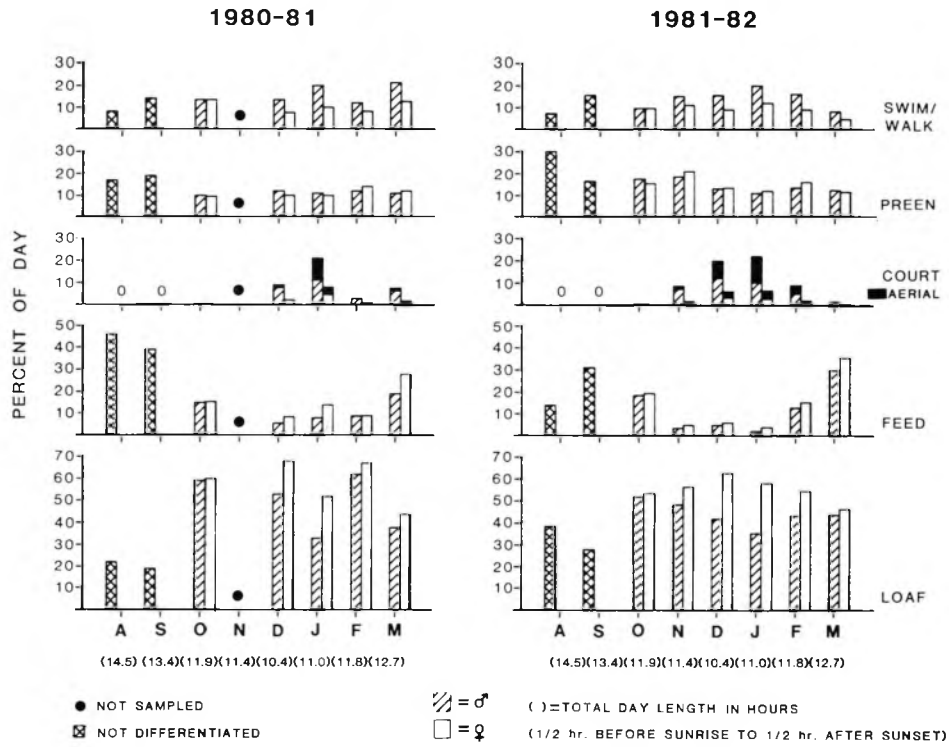

Figure 3. Proportion of each day-interval allocated to various activities by Northern Pintail during winter 1980–81 (dry) and 1981–82 (wet). Data for months combined (excludes August and September).

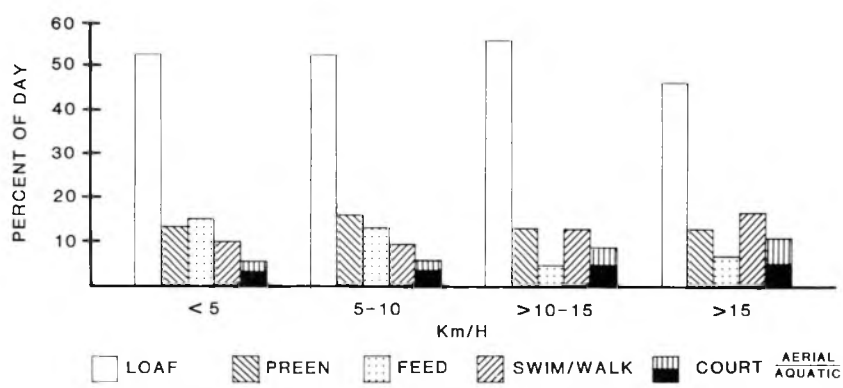

Figure 4. Proportion of the average day allocated to various activities by Northern Pintail relative to wind speed (km/h). Data for field seasons, day-intervals, and sexes combined; August and September excluded.

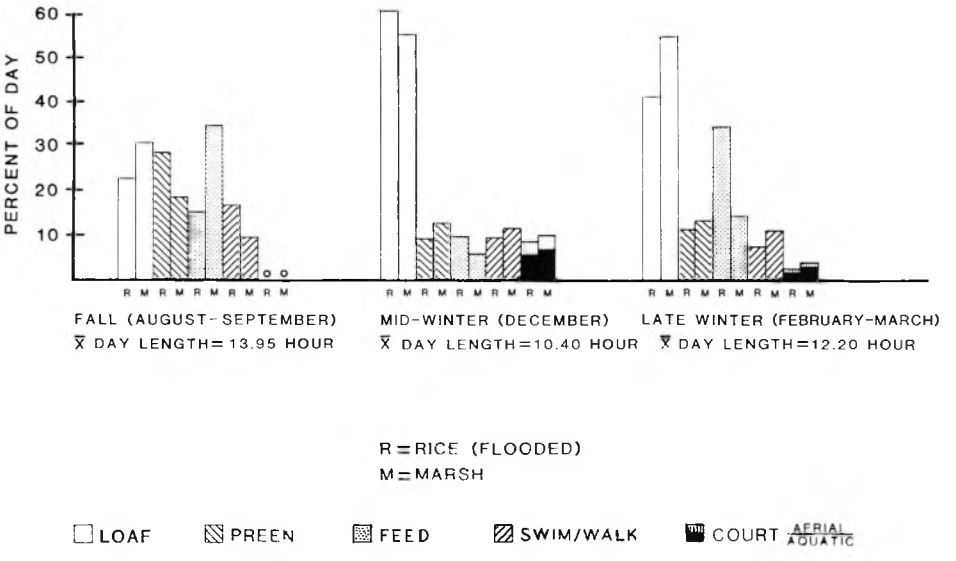

Figure 5. Proportion of the average day allocated to various activities by Northern Pintail on marsh and flooded rice habitat. Data for seasons, sexes, and day-intervals combined.

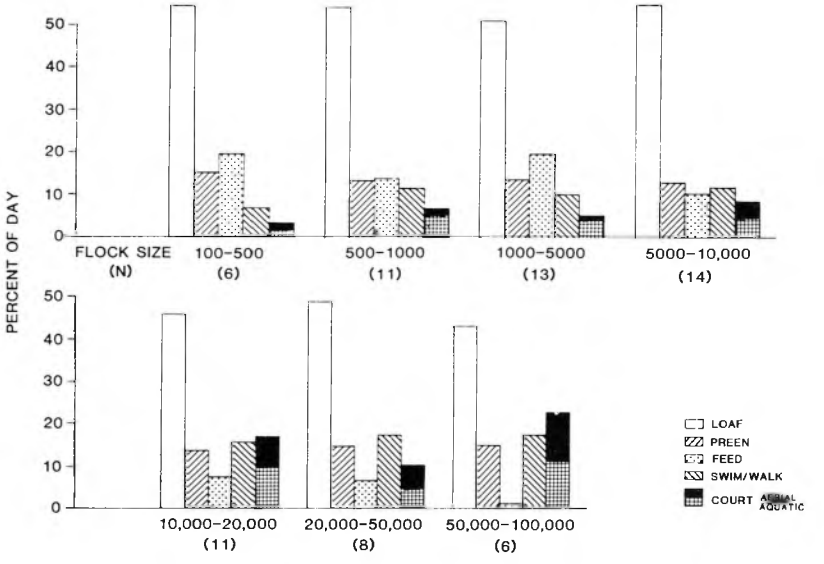

Figure 6. Proportion of the average day allocated to various activities by Northern Pintail relative to flock size (August and September excluded). Data for seasons, day-intervals, and sexes combined. Number of flocks in parentheses.

Generally females fed more frequently than males from November through March (not November 1980 or February 1981) (Figure 2), and during most day-intervals (Figure 3). Feeding was most frequent from midmorning to afternoon.

Pintail fed about three times more frequently if winds were 10 km/h or less (Figure 4). They fed more often in marsh during August and September, but in rice during mid- and late winter (Figure 5), and most frequently in flocks of less than 5,000 birds (Figure 6).

(iii) Feeding flights

During August and September, Pintail flew (< 4 km) from roost ponds to refuge rice crops well before sunset (Figure 7), spending about 1.8 hours in the rice before returning to roosts. Flights occurring prior to sunrise also were observed. Beginning in October, feeding flights to harvested rice fields off refuge occurred after sunset. Flights of many kilometres were not unusual. Ducks normally returned to refuge roosts within the hour before sunrise. Sunset was 1.5 hours earlier in October than in August, but the midpoint of peak flights was only about 20 minutes later than in August. From November through March, the midpoint of flights was 30 to 45 minutes after sunset.

(iv) Courtship

Courtship began in October and aerial displays were first recorded in November (Figure 2). Courtship was most frequent in December and January, up to 2.5 hours/day for males and almost three-quarters of an hour for females. Few aerial displays were observed in December 1980, whereas one-third of all courtship was aerial in December of the wet winter. Courtship frequency in December of the dry winter was one-third to one-half that of the following January (when rainfall was normal), and less than half the level recorded in December of the wet year. Pintail courted with greatest frequency during predawn through mid-morning (Figure 3), at high wind speeds (Figure 4), in marsh habitat (Figure 5), and in flocks exceeding 5,000 birds (Figure 6).

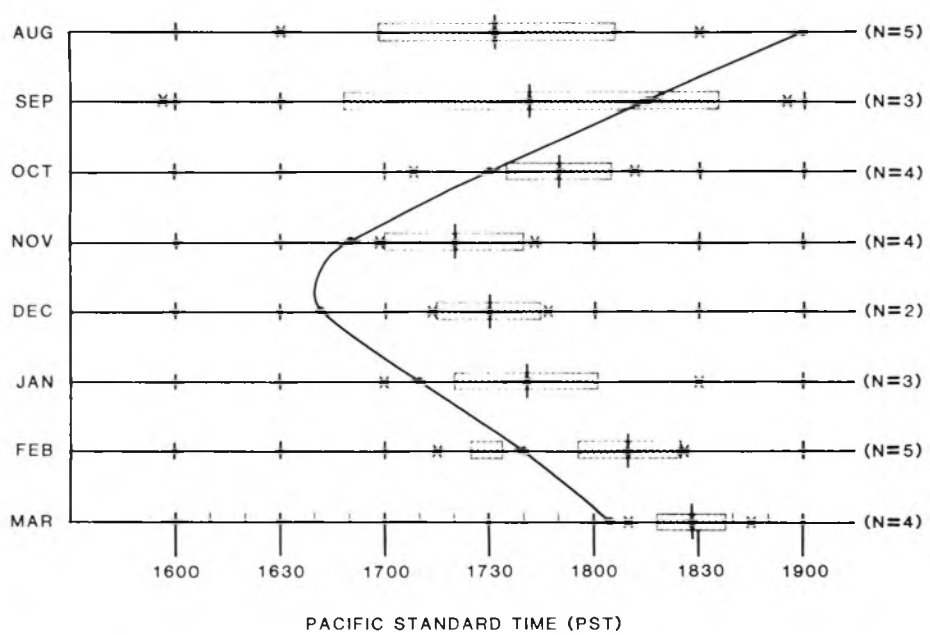

Figure 7. Evening feeding flight times (Pacific Standard Time) of Northern Pintail leaving the Sacramento Valley National Wildlife Refuges to feed in harvested rice fields (data for field seasons combined). Time of sunset (black dot); moderate to heavy flights (cross-hatched); midpoint of heaviest flights (vertical line through cross-hatching); range of flight times (x).

At Sacramento N.W.R., about 55% of female Pintail were paired by mid-November, 83% by mid-December, 93% by late December through January, and 96% by mid-February 1982–83 (J. Y. Pirot, pers. com.). In my study nearly 70 copulations were observed, most in January (49%). Only three copulations were observed in October and November. The remainder (46%) were distributed equally in December, February, and March.

A total of 1,990 Pintail courtship flights were analysed from November through February, with 4.2 ± 1.3 ($\bar{x}$ ± S.D.) males per female (Figure 8). Three, four, and five males per female accounted for 77% of flights observed. In January, a larger percentage of flights contained five or more males (45% versus 37%). Mean duration of 10 flights was 2.2 ± 0.9 minutes.

(v) Preening

More time was allocated to preening during August, September, and February than other months, and during October through February of the wet than dry winter (Figure 2). Males and females spent similar times preening. Preening was most frequent early and late in the day (Figure 3), and when wind was between 5–10 km/h (Figure 4). Flock size had no effect on preening (Figure 6). Pintail preened most frequently in rice ponds in August and September and in marshes in midwinter, but no difference was found in late winter (Figure 5).

(vi) Locomotion and other activities

Time spent swimming and walking was minimal in August, but males increased these activities during January (Figure 2) and locomoted more than females. Nearly twice as much time was spent swimming or walking during predawn, dawn, and sunset than during midday through evening (Figure 3).

Pintail increased locomotor and aggressive activity at wind speeds above 10 km/h (Figure 4). Swimming was most common in rice ponds during August and September, but in marshes in late winter (Figure 5). Swimming and walking were most frequently observed in flocks exceeding 10,000 birds (Figure 6).

Alertness, bathing, diving, drinking, flying, and aggression together accounted for less than 5% of all diurnal activities during most months.

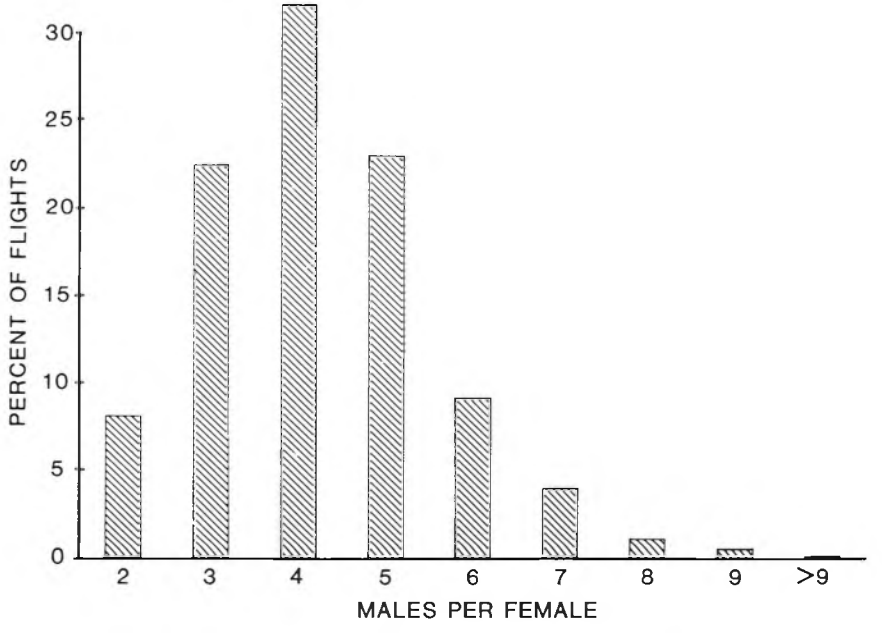

Figure 8. Frequency distribution of the number of males per female in Northern Pintail courtship flights during winter of 1980–81 and 1981–82. Data for months pooled, N = 1990.

Discussion

Populations

Mild climate and abundant food support large Pintail populations in the Sacramento Valley during winter, and facilitate social interaction (courtship) critical to subsequent nesting and breeding success. Sex ratios near parity as winter progressed reflected the mild climate, since in severe cold males predominate (Bellrose *et al.* 1961; Alford & Bolen 1977; Jorde *et al.* 1984).

Activities

Time spent loafing (October–March) by Pintail during this study (4.7–7.6 hours/day, sexes combined) was similar to that in Senegal (6–8.5 hours/day, November–March; Roux *et al.* 1978), and to that of several other dabblers (3–9 hours/day; Tamisier 1972, 1974, 1976; Roux *et al.* 1978; Campredon 1981, 1982; Jorde *et al.* 1984; Quinlan & Baldassarre 1984). However, Gadwall *A. strepera* in Louisiana spent only 11% of the day loafing because of foraging requirements (Paulus 1984). Physiological requirements for rest are not known, but may change seasonally in response to changing bioenergetic requirements (Tamisier 1972). If time allocated diurnally is not adequate, as when photoperiod is reduced in midwinter or daylight is used increasingly for other activities, Pintail could sleep at night. However, dabbling ducks sleep little then (European Wigeon *Anas penelope*, Campredon 1981;Gadwall, Paulus 1984; European Green-winged Teal *A. crecca crecca*, Tamisier 1972).

In general, time spent loafing by Pintail was related to time allocated to more active behaviour. For example, Pintail spent much of the day feeding in August, September, and March, and courting in December and January, so time remaining for loafing was reduced. Similar time budget adjustments were recorded by the other authors for European Wigeon, Green-winged Teal, and unpaired Gadwall males. Midday rest periods are common for dabbling ducks (Tamisier 1972; Paulus 1984; Quinlan & Baldassarre 1984). Female dabbling ducks generally loaf more than males, and female Pintails may have spent more time loafing, especially in December and January, to conserve energy and because they courted less than males.

Diurnal foraging was important to Pintail and other dabblers (Paulus 1984; Quinlan & Baldassarre 1984), contrary to the conclusions of Tamisier (1976). Frequent diurnal feeding from August through September replaced depleted body nutrient content (M. Miller, unpubl. data; Tamisier 1972, 1974; Campredon 1981). Foods were not yet available in harvested fields, so demand had to be met on refuges. Northern Shoveler, Green-winged Teal, and Mallard fed frequently during early fall in California (R. Titman, pers. com.), as did Green-winged Teal (Quinlan & Baldassarre 1984). Feeding time in August 1980 and 1981 should have been similar, but the timing of observations influenced results. Feeding activity had declined after a week of constant use of the habitat during August 1981, whereas in August 1980 observations were made only two days after ponds were flooded and Pintail had just begun to use the areas for foraging. Foraging in refuge rice crops during August and September was not random, the birds forming large, tightly packed flocks, systematically consuming several hectares of rice each day. The short time spent in refuge rice consisted primarily of loafing, swimming, and preening, so ducks were able to obtain food rapidly.

Pintail reduced diurnal foraging in midwinter, a time of low ambient temperatures (6–8°C daily mean) and minimal body weight (M. Miller, unpubl. data), as did Mallard (Jorde *et al.* 1984) and European Wigeon (Campredon 1981). Refuge foods are normally depleted then (refuge reports), and foraging is often unsuccessful (M. Miller, unpubl. data). Pintail reduced feeding early in the day after September because the ducks were not in immediate need of additional energy after nocturnal feeding (von Känel 1981).

Pintail increased diurnal foraging during February and March to add dietary protein (M. Miller, unpubl. data) to facilitate rapid weight gain before spring migration (McLandress & Raveling 1981). Increased feeding by dabbling ducks in late winter to replenish body reserves is common but not universal. Increased diurnal feeding by Pintail in late winter may have been related to shorter nights (Tamisier 1976).

Female Pintail fed more frequently than males during late winter in the Sacramento Valley to provide nutrients for feather growth in prebasic moult, and fat storage for

migration and egg production (Krapu 1981). Females fed and loafed more, courted less, and consequently lost less weight than males (M. Miller, unpubl. data). Female Pintail and Green-winged Teal in Louisiana (Tamisier 1974, 1976) and Mallard in Nebraska (Jorde 1981) fed more than males, but differences by sex are not always evident in winter (Quinlan & Baldassarre 1984; Paulus 1984).

Pintail courtship was most frequent in January in the Sacramento Valley as in North Carolina (Hepp & Hair 1983) and Louisiana (Tamisier 1976), but from mid-December to mid-March in Texas (Smith 1968), and November in Suisun Marsh near San Francisco (J. Y. Pirot, pers. com.). Sexes were segregated until mid-December in Texas, but segregation did not occur in California. Seasonal timing and intensity of courtship, and thus pair formation, probably depends on latitude, age and sex ratio, physical condition, migration chronology, age of first breeding, and nest initiation date (Paulus 1983), as well as sufficiency of food supply (Brodsky & Weatherhead 1985), habitat, weather variables, and flock size.

Predominance of males in courtship resulted from the male biased sex ratio, localised concentration of unmated males, and, importantly, regular participation of paired males. Rates of pair formation for Pintail were nearly equal in the Sacramento Valley, Texas (Weller 1965), Suisun Marsh (J. Y. Pirot, pers. com.), and North Carolina (Hepp & Hair 1983), although peak periods of courtship were different. Either paired males in different areas participate in courtship at different frequencies, or observer bias influenced whether or not females were recorded as paired. Pairing may increase winter survivorship, if pairs are dominant over other social classes (Paulus 1983; Hepp & Hair 1984).

An increased proportion of courting flights with more than four males/female coincided with most intensive courtship (January), and may have reflected increased (but delayed) participation by immature males (Blohm 1982).

The relatively high copulation rate observed in Pintail in North Carolina (Hepp & Hair 1983) and California contrasts with an absence of copulations among Pintail wintering in Texas (Smith 1968). This may be a function of different peak courting periods among areas or sample sizes. In the Sacramento Valley and North Carolina, intensive courtship activity and greatest number of copulations occurred in January, when the percentage of paired females was nearing winter maximum. Thus, copulation may reinforce pair bonds "tested" by courting parties (Derrickson 1977).

Pintail allocated time to preening in relation to progress of prealternate moult, which peaks in October and November (Miller, in press), as concluded by Tamisier (1974), Paulus (1984), and Quinlan & Baldassarre (1984). Prebasic moult of females in February was likewise accompanied by increased preening. However, males, which did not undergo February moult, also increased preening then, so other factors were involved.

Pintail increased swimming and courtship concurrently in January, as shown for Pintail in Louisiana (Tamisier 1976), because members of courtship groups swim or walk when males are not actually displaying. Increased swimming and preening early in the day was associated with return from nocturnal field feeding and courtship, and late in the day with restlessness before evening flights. Pintail in Louisiana exhibited similar behaviour. Pintail seldom engaged in activities other than those discussed characteristic of most dabbling ducks during winter. However, estimates of time spent flying must be very conservative, because flying Pintail, except at take-off or landing, were not sampled. Most flying was associated with feeding flights or changing locations during storms.

Feeding flights

Pintail, Green-winged Teal, European Wigeon, Garganey *Anas querquedula* (Tamisier 1970, 1972, 1976; Roux *et al.* 1978; Campredon 1981) and Mallard (Sacramento Valley; M. Miller, pers. observ.), but not Gadwall (Paulus 1984), regularly participate in evening flights to nocturnal feeding areas. Pintail flights suggest that roosting and feeding areas in the Sacramento Valley could be geographically integrated as "functional units" (Tamisier 1978/79). Nocturnal feeding by Pintail and other dabblers in the Sacramento Valley contrasted with morning and evening flights of Mallard, Black Duck *Anas rubripes*, Green-winged Teal, American Wigeon *A. americana*, and Pintail feeding on upland sites in colder

climates (Bossenmaier & Marshall 1958; Winner 1959; Thomas 1981; Baldassarre & Bolen 1984). Sacramento Valley Pintail made morning flights only when rice was available on refuges in August and September.

The shooting season began in October a few days prior to collection of that month's flight data. The midpoint of flights shifted only slightly from August through October and occurred coincidentally just after sunset. Therefore, shooting may have been responsible for only a narrowed range of time over which flights departed. After the open season, post sunset flights continued, supporting the idea that their initiation was minimally related to hunting. The few flights that began prior to sunset after October were on rainy, windy days (Raveling *et al.* 1972, Tamisier 1976). Evening flight times were completely independent of shooting for Green-winged Teal and Wigeon in France (Tamisier 1970, 1974; Campredon 1981), Pintail and Green-winged Teal in Louisiana (Tamisier 1976), and for Pintail and Garganey in Senegal where little hunting occurs (Roux *et al.* 1978; A. Tamisier pers. com.).

From November through January, initiation of flights 30 minutes after sunset ensured that the maximum time was available for nocturnal foraging during the long nights of the coldest time of year when nutritional demand was high and food probably difficult to obtain. Continued post sunset departures reduced nocturnal feeding time in February by one hour and in March by two hours compared with January, but diurnal feeding may have compensated.

Comparison between years

Pintail loafed and fed (diurnal) more, and courted and swam less to conserve energy during portions of the dry winter in response to probable food shortages associated with poor habitat conditions. Rice, which sustains Pintail throughout winter (M. Miller, unpubl. data), was probably more available during the wet year because harvested fields were not ploughed and flooding made fields more attractive feeding areas. In fact, Pintail weighed and moulted (females) less during the dry than wet year (M. Miller, unpubl. data). Thus, additional foraging on refuges during the dry winter may have supplemented foods obtained nocturnally. Pintail increased diurnal feeding and courtship in January of the dry winter after near normal rainfall improved habitat conditions. Perhaps Pintail courted more frequently in response to increased food supply as shown for Black Ducks (Brodsky & Weatherhead 1985). Mallard also varied activities annually in relation to habitat conditions (Jorde *et al.* 1984).

Wind speed, habitat, flock size

Wind chill was not severe enough in the Sacramento Valley to require energy conservation behaviour typical of geese (Raveling *et al.* 1972; Burton & Hudson 1978); high winds stimulated energy costly social interactions, swimming, and flying. Feeding declined as wind stimulated increased courtship.

During August and September, Pintail filled their oesophagi more quickly by stripping rice seed heads than by up-ending for native seeds in shallow water. By midwinter, geese and ducks had completely denuded rice ponds of seed and stalks, creating open habitat; differences between frequency of activities in rice ponds and marshes were then minimal. In February and March, it became warmer and ponds became excellent sources of invertebrates, and more time was spent feeding in rice ponds. More frequent courtship display in marsh than rice ponds throughout winter resulted from large flocks of Pintail on the larger expanses ($>$ 300 ha) of open marsh habitat, compared with small flocks on the smaller (10–20 ha) rice ponds.

Diurnal gregariousness may facilitate courtship (Tamisier 1970), with more opportunity for such interaction in large flocks. Courting flights rarely strayed far from the main flock, increasing participation by many males. After September, Pintail fed most frequently in small flocks ($<$ 5,000) similar to Pintail and Green-winged Teal in Louisiana (Tamisier 1976), probably because large roost areas had been depleted of foods.

Management implications

Pintail have remained abundant in the Sacramento Valley during fall and winter despite severe habitat losses because the mild climate, abundant food produced by intensive marsh management, and waste grain in harvested fields have created

suitable conditions. However, continued loss of habitat (Gilmer *et al.* 1982) will not be beneficial. Seasonally variable resource requirements must be met during winter and should be incorporated into Pintail habitat planning.

Diurnal gregariousness resulting in courtship and nocturnal feeding in harvested rice fields is facilitated by the large flocks which form on extensive wetlands (> 300 ha) not subject to disturbances from shooting, bird-watching, refuge maintenance activities, etc. Such habitat is not common in the Sacramento Valley except in very wet winters, and needs enhancement.

Feeding was a regular diurnal activity of Pintail, particularly during the dry winter, and may have been important to supplement rice. Food should thus be made available on the roosting areas.

Abundant food is required in fall to provide for accumulation of body reserves for survival and courtship activity in midwinter. Habitat conditions conducive to courtship may be important for pair formation and annual recruitment. Foods important in late winter (invertebrates) should be increased.

Provision of favoured loafing sites away from shooting areas and visitor tour routes would probably increase the use of habitat by Pintail.

Sampling of time budgets should be done on days of similar wind conditions to avoid biases.

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Summary

Diurnal time budgets of Northern Pintail *Anas acuta* were quantified from instantaneous scan samples of flocks in the Sacramento Valley, California. Data were collected from August through March in 1980–81, an unusually dry winter, and in 1981–82, a very wet winter with abundant flooded habitat. Sustained populations of up to 250,000 Pintail were recorded. Sex ratios favoured males (94%) in August, but neared parity by December. Females loafed and fed more frequently than males, while males swam and courted more than females. Diurnal feeding was frequent except during midwinter. Courting was most intense, up to two hours per day for males, in December and January, and was most frequent early in the day. Courtship flights averaged 4.2 males per female and copulations were most frequent in January. Courtship activity (substantially reduced during December of the dry winter) was most frequent early in the day, succeeded by loafing then feeding. Time spent feeding and loafing was higher in midwinter of the dry than wet winter.

Time spent courting and swimming increased, but feeding and loafing decreased, at higher wind speeds and in large flocks. Feeding was more frequent in marsh habitat in August and September, but in flooded rice in February and March. Less time was required to obtain food from refuge rice crops than from marshes. Courtship activity was most common in marsh habitat and in large flocks.

Feeding flights in the morning and well before sunset were noted in August and September, when ducks were feeding on crops provided by the refuges, but after sunset from October through March, when feeding took place nocturnally in harvested rice fields. Shooting minimally influenced the timing of feeding flights.

Diurnal feeding is important in the Sacramento Valley and appropriate foods should be increased. Behavioural changes suggest that food, a function of habitat availability, may be in short supply in dry years. Maintenance and enhancement of large marsh tracts are needed. Loafing, the dominant activity in winter, could be facilitated by increasing suitable sites.

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