Golden Eagle

Aquila chrysaetos

1. INTRODUCTION

The British golden eagle population is largely confined to the remote mountainous areas of the Highlands and Islands of Scotland, north and west of the Highland Boundary Fault (Watson, 1997). A few pairs occur in the Southern Uplands of Scotland and northern England. The species is absent from Orkney and Shetland. A reintroduction scheme began in 2000 in Ireland (Ó Toole *et al*., 2002; www.goldeneagle.ie) and the first chick fledged successfully in July 2007. Established pairs of breeding golden eagles in Britain are largely sedentary (Watson, 2002). Juveniles and immature birds can disperse over distances in excess of 150 km from their natal area, and immatures are nomadic before reaching breeding age and maturity at 4–5 years. Females are larger than males but the sexing of single birds visually is unreliable. Immature birds have white patches on the underwing and the base of the tail (e.g. see descriptive notes for the golden eagle survey form in Appendix 3). Occasionally, a bird in sub-adult plumage is found breeding.

For further information on the biology and ecology of this species, Watson (1997) provides a comprehensive account. Whitfiled *et al*. (2008a) reviewed the conservation states of the Scottish golden eagle population and identified illegal persecution (principally associated with grouse moor management in the central and eastern Highlands) and low food availability in the western Highlands, as key constraints.

Annual cycle

Breeding Activity	Peak Period	Range	Duration (days)
Occupation of home range		All year	
Territorial display		January to March	
Nest building	January to March	October to March	
Egg laying	Mid-March to early April	Early March to mid-April	3 to 6 (for clutch of 2)
Incubation	Mid-March to mid-May	Early March to early July	41 to 45
Hatching	Late April to early June	Mid-April to early July	
Young in nest	Late April to early August	Mid-April to mid-September	70 to 80
Fledging		July to mid-September	
Juvenile dispersal		August to January	

2. HABITAT, HOME RANGE, NESTS AND BREEDING

2.1 Habitat

Golden eagles occupy a range of habitats, from open montane areas, through Caledonian pine woodland to island seacliffs. They are closely associated with mountainous areas, and unenclosed and unimproved habitats such as deer forest and upland sheep-walk. They can also be found on actively managed heather moorland in central and eastern Scotland, and in the vicinity of enclosed pasture and coastal areas in the west of their range.

2.1 Home range

Adult golden eagles hold more-or-less exclusive home ranges that encompass both their hunting range and nesting territory, are occupied all year round and actively defended against intruding eagles (Watson, 1997; Crane & Nellist, 1999, 2003), which are aggressively attacked and pursued. In areas of continuous suitable habitat, the nesting ranges of neighbouring pairs are usually spaced at regular intervals. In Scotland, breeding densities are influenced by the availability of live prey and carrion (Watson *et al*., 1992; Fielding *et al*., 2003a; Whitfield *et al*., 2008a), ranging between about 4-25 pairs per 1,000 km^2 (Watson, 1997). Based on radio-tracking and intensive observations, home range sizes in western Scotland have been estimated at 864-6,687 ha (Haworth *et al*., 2006) and a predictive model of home range use has been developed (McGrady *et al*., 2002; McLeod *et al*., 2002a, b).

2.2 Nest sites

Scottish golden eagles nest predominantly on crags (96%); tree nesting (4%), typically in an old mature Scots pine, occurs mainly in the eastern Highlands (Watson, 1997). Nest sites can be found at altitudes of under 200 m ASL near the western seaboard, rising to around 800 m ASL in the eastern Highlands (Watson & Dennis, 1992; Whitfield *et al.*, 2008a). Nests are not necessarily built in the most inaccessible position or on the highest cliff; the advantages in nesting higher to reduce predation risk and possibly human persecution are likely to be balanced against the disadvantages of transporting heavy prey uphill (Watson, 1997). Nests are generally located at about half the maximum elevation of the surrounding land. Thus nests may be found on small crags, often in a walk-in position. Most crag nests have a northerly or easterly aspect, probably a reflection of past glacial action on the land rather than active selection by the birds (Watson, 1997).

2.3 Nests

Territories may have 1–13 (normally 1–6) alternative nests (Watson, 1997). Nest material is added to one or more of these year after year, and some eyries can become extremely large, particularly those in trees. The size of the nest can vary from a pad of soft material on a vegetated ledge to a pile of sticks 2 m or more in height. Most nests are constructed of sticks and/or heather, with a soft lining of woodrush and grasses. On a nesting crag, many nests are obscured by vegetation or beneath a rock overhang and are easily overlooked. Old nests have a grey appearance and will often have green vegetation growing through within a year of non-use. Some nests have completely decayed after 10 years without addition of new material, although their position may be identifiable for some time after this.

2.4 Clutch size and incubation

Egg laying in Scotland occurs between early March and mid-April (Watson, 1997). February temperatures can have an impact on laying date; Watson (1997) showed that in the years when February was coldest, laying was around 10 days later than in the warmest years. In Scotland, golden eagles lay 1–3 eggs. Most clutches are of two eggs, with 1-egg clutches quite

frequent and 3-egg clutches comparatively rare (Watson, 1997). The laying interval between eggs is 3–5 days (Gordon, 1955). Relays are rare but may occur if the first clutch is lost early in incubation. Incubation commences with the first egg, lasts 41–45 days and is normally undertaken by the female, relieved for short periods by the male during daylight hours. A study in Idaho found that females incubated for 83% of daylight hours compared with 14% by males, with males relieving females on average twice a day for about 50 minutes on each occassion (Collopy, 1984). The male does not generally feed the female during incubation.

2.5 Brood size and fledging

The normal brood size in Scotland is one, although broods of two are frequent (Watson, 1997) and broods of three are occasionally found in the eastern Highlands. In nests with more than one chick, the younger and weaker chick may die or be killed as a result of competition or aggression from its larger sibling (Edwards & Collopy, 1983). Smaller broods are associated with poorer food supplies and poor weather conditions. In Scotland, young eagles usually spend around 70–80 days in the nest (Watson, 1997). Studies in America have reported overall average delivery rates of 0.9–1.8 prey items per day during the nesting period, with males bringing over 80% of deliveries during the first two weeks after hatching while the female delivery rate gradually increases to about 50% as the requirement to brood nestings decreases (Watson, 1997). A study in Idaho reported a peak of provisioning in week eight when three items were delivered per day (Collopy, 1984). For the first few weeks after fledging, young eagles generally stay within about 100 m of the nest site (Watson, 1997). They seek out a secure perch such as a wooded ledge or tree branch and can be surprisingly inconspicuous except when food calling. Thereafter, juvenile eagles spend a variable period on their parents' territory, extending from days to several months, before dispersing.

3. SURVEY TECHNIQUES

CAUTION *To minimise disturbance, initial checks of nest sites at all stages should be made from a distance of 750 m to 1.5 km away (Ruddock & Whitfield, 2007; Whifield et al., 2008b), for example a vantage point at the opposite end of the glen which gives a clear view of the eyrie. Nests should not be approached in March and early April, as golden eagles are particularly sensitive to human disturbance just before and during egg laying. Disturbance behaviour typically involves both birds circling together to a great height and often drifting away from the nest crag. Later in the season, observers should avoid nest disturbance during particularly hot, wet or cold conditions, as the absence of adults from the nest for extended periods may result in chilling or overheating of eggs or young. Site checks are best undertaken on dry, overcast days. Well feathered young (about 50 days or older) in the nest should not be approached as they may fledge prematurely. Appropriate health and safety precautions should be undertaken if nest visits require climbing (see Section 7.1 of Introduction).*

3.1 Breeding season visit schedule

The species is listed on Schedule 1 in Great Britain, Northern Ireland and the Isle of Man (see Section 7.1.1 of Introduction). In addition, golden eagle is listed on Schedule ZA1 of the Natural Environment and Rural Communities Act 2006 (England and Wales) which gives year-round protection to nest sites. To establish occupancy and the presence of a breeding pair, it is recommended that each home range is visited on at least four occasions. If time for fieldwork is limited and an observer believes a home range to be vacant on the basis of the first two visits, however, then subsequent visits can be omitted. A copy of the recording forms distributed to fieldworkers taking part in the 2003 survey of golden eagles in Great Britain is included in Appendix 3.

Visit 1	January to early March	To check for occupancy.
Visit 2	April	To locate active nests.
Visit 3	June	To check for young.
Visit 4	Late July	To check for fledged young.

3.2 Signs of occupancy

3.2.1 Locating home ranges

Ideally, historical data should be collected to identify all known eyries in the area to be surveyed, as the birds are often quite traditional in their use of nesting sites (Watson *et al*., 1992). Territories can be located during the autumn and winter months and checked for occupancy on visits between January and early March, before laying commences.

Golden eagles generally display less than other *Aquila* species but such displays can nevertheless be useful in finding territorial birds. Lone birds or pairs often high-circle to hundreds of metres above the ground, particularly on fine days in winter and early spring (Cramp & Simmons, 1980). Flight-play between a pair does occur but is infrequent. Mutual high-circling may be accompanied by a series of long dives by both birds, as well as some mock-attacks and fast manoeuvres high up. Undulating sky-dancing (high-circling, rapid diving and swooping) is frequent, particularly in late winter and early spring but also at times throughout the breeding cycle. It is performed by both sexes but probably more frequently by males (sometimes by pairs). Local topographical features (e.g. ridges, mountain tops) are often used to perform over. Calling is not a regular feature of golden eagle flight displays, although it may be heard occasionally during sky-dancing or high-circling.

The amount of golden eagle activity seen can vary greatly; birds can be active or idle at any time of day. Moreover, the presence of a breeding pair can be easily overlooked. It follows that the lack of any sightings during any one visit should not be regarded as evidence of a vacant territory or non-breeding (see Section 3.4). Evidence of recently used roost sites, fresh droppings or prey remains (Section 3.2.2 and 3.2.3), and/or a recently built-up nest can indicate the presence of golden eagles and may be signs that the territory is occupied, even if no birds are seen. Initial territory checks are best made from vantage points affording wide overviews of likely foraging areas. These vantage points should be on lower ground looking towards ridges and glen heads. Watches should last up to 4 hours and should be repeated on a subsequent visit if no birds are seen; they are best made in the period leading up to dusk to watch for birds returning to their roosts.

3.2.2 Locating roosts

Active roosts in an occupied territory can be in trees, on ledges or on rocks. They are marked by pellets (which decay rapidly), faeces (splash that washes away in rain) and down and feathers. These signs can be ascribed as fresh (soft faeces, new fluffy down and feathers), recent (dried faeces and matted down and feathers) and old (mildewed signs). Roosts may be up to 3 km from an occupied nest, so the presence of an isolated roost is not evidence for non-breeding or failure. Winter roosts may be close to the edge of a home range rather than within the core.

3.2.3 Recognition of signs

Fresh golden eagle plucks show large pluck marks, usually in a neat and tight pattern. Such marks cannot generally be distinguished from those of the white-tailed eagle, however, and only remain intact in recent kills and in the absence of wind to disturb the feathers. Golden eagle pellets also should be identified only in association with other signs (e.g. moulted

feathers), as they are similar to those of white-tailed eagles. Even if the pellets contain fish bones, there is no guarantee that they are not from golden eagle.

3.2.4 Evidence of occupancy

For the 2003 survey of Great Britain, a home range was considered to be occupied if a pair of birds that could potentially breed was seen together or if there was evidence of a breeding attempt, including sighting(s) of a single bird in combination with a newly built-up nest (Eaton *et al*., 2007). For the previous (1992) survey, ranges were recorded as occupied by pairs only if both birds were seen (Green, 1996).

3.3 Evidence of breeding

In addition to the location of an active nest or fledged young, the precence of a freshly built-up ('greened-up') nest in combination with sightings of a pair of golden eagles or a single bird provides evidence of a breeding attempt (Eaton *et al*., 2007).

3.3.1 Locating active nests

The breeding year starts early for golden eagles and pairs can be seen refurbishing nests and engaging in display and territorial disputes on bright days in mid-winter. Nest building and repairs to existing structures reach a peak in January and February, in the lead up to egg laying. Nests should not be approached in March and early April, as the species is particularly sensitive to human disturbance just before and during egg laying (Tjernberg, 1983). Disturbance behaviour typically involves both birds circling together to a great height and often drifting away from the nest crag. If the eagles show signs of disturbance, the observer should move away as quickly as possible.

Vantage point watches on one or more visits during March and April should be used to confirm breeding activity. All known eyries should be checked for the presence of an incubating bird, a single bird rising above a nest site on approach, or for signs of fresh nest material. An incubating adult will often sit tightly, particularly if the off-duty mate is absent from the nesting territory. A lack of sightings but the presence of signs of roosting birds may indicate that a pair is occupying a range but is preparing nest sites away from those being checked. If no occupied nest is found, all crags and suitable woodland should be checked by scanning from a distance with a telescope or binoculars. The active nest may be on an inconspicuous crag low down in the homerange, especially if an area is not subject to regular disturbance. When an active nest is located, it is unnecessary to disturb an incubating bird unless there is a specific requirement to collect information on clutch size. In these circumstances, the fieldworker should deliberately make a noise on approach to the eyrie, to alert the sitting bird and allow it to leave without panic.

When an active nest is located within a traditional home range, the possibility of more than one breeding pair of golden eagles being present should not be discounted. The splitting of home ranges can occur, particularly of larger ranges and when food abundance is high. Therefore, all known nest sites in a nesting range should be checked, even if an active nest has been found.

3.3.2 Evidence for fledging

Subsequent visits to occupied eyries should be made to record the number of young in June and fledged young in late July, or if an occupied nest has not been found, to confirm that the birds have failed or are not breeding. If a nest is inaccessible, counting young will require climbing (see Health and Safety information in Section 7.10 of Introduction) and care should be taken in the timing of visits to minimise the risk of causing premature fledging.

Well-feathered young of at least eight weeks old are the minimum requirement for a presumption of fledging. Successful nests can be identified in late summer and autumn by their flattened nature and the presence of nestling down, faecal material and prey remains.

When young are likely to be close to fledging, nests should be viewed from a distance with binoculars or a telescope as disturbance at this time may cause premature fledging or fledged young to move from perches where they are safe from ground predators. Walking the ground is not recommended as eaglets can remain still, silent and inconspicuous, even if an observer passes only a few metres away. Alternatively, disturbed, eaglets may panic and injure themselves, for example by attempting flights over distances they are not yet capable of sustaining and landing awkwardly. Fledged eaglets tend to move uphill from the nest and can be located by scanning from a distance for signs such as down. It may be necessary to wait until an adult brings food to get a clear view of the young, either in a nest or after fledging, which may require several hours of observation (Gilbert *et al*., 1998).

An empty nest with a fresh lining is not necessarily indicative of breeding failure because immatures and single adults may nest build without breeding, or the pair responsible may be using an alternative but unknown eyrie. A well-built nest together with the presence of an adult bird is considered strong evidence of attempted breeding, however. If possible, suspected failed nests should be examined at the end of the breeding season for any clues, such as deserted eggs or shell fragments, dried splash and down. This evidence may be hidden under fresh nest material added by the adults after failure.

3.4 Evidence of non-breeding

A relatively high proportion of Scottish golden eagle pairs do not lay eggs in a given year although it is difficult to be precise because some pairs which appear not to have laid may have lost eggs early during incubation (Watson, 1997). This incidence of non-laying (or early egg loss) was found to be higher in two western areas (average 26%) compared to an area in the eastern Highlands (average 12%; Watson, 1997). Non-breeding can therefore be difficult to prove. Repeated sightings of a pair together away from nest sites during the incubation period and no sign of an occupied nest after extensive searching (checking all known nest sites and searching all potential new areas for an active nest throughout the breeding season) provides good evidence of non-breeding. Sightings of a single bird only on a number of visits may indicate the presence of a non-breeding bird. Information on the distribution of non-breeding birds is extremely valuable, as these are potential recruits to the breeding population.

3.5 Ageing and sexing young

The age of chicks may be estimated very approximately from a distance by plumage development (Watson, 1997). Up to about 25 days, chicks are covered in down and appear whitish from a distance. Between 25-50 days the dark contour feathers gradually eclipse the white down and for much of this phase the bird has a piebald appearance. The last of the down is lost from the head and neck. From 50 days onwards, the main growth period for the feathers of the wing and tail, the young are a uniform dark brown, Late in the nestling period the plumes on the back of the neck become fully developed. Photographs of golden eagle chicks in the nest at a range of ages are shown in Plates 58–63.

Measurements of a sample of immature golden eagles of the North American race *canadensis* (Bortoletti, 1984) suggest that it may be possible to sex large, well-grown young that are handled for ringing purposes by measuring the length of the hallux (rear) claw and culmen (Table 5). There is a degree of overlap in both measures but, when used together, these should provide an indication of the sex of most well-grown chicks. Edwards & Kochert (1986) used foot span from dead adult golden eagles of known sex and found this measurement 100% accurate for sexing. A growth curve (Figure 27), again using data collected from North America (Ellis, 1979), could be useful in ageing young. Asymptotic mass, reached at 45–50 days old when the rate of increase in weight levels off (Figure 27), might also be a useful

criterion for sexing many chicks: at this stage females are typically 500–600 g heavier than males (Watson, 1997). All of these methods need to be tested further on Scottish eagles before general acceptance, however.

Table 5. Measurements of immature golden eagles: hallux and culmen (Bortoletti, 1984); and foot span of autopsied adult birds (Edwards & Kochert, 1986).

	Male		Female	
	Mean (mm)±SD	*Range*	*Mean (mm)±SD*	*Range*
Hallux claw length	47.75 ± 1.62	44.9–51.3	54.01 ± 2.15	49.7–58.2
Culmen	39.36 ± 1.44	36.2–42.6	43.34 ± 1.36	39.9–50.0
Foot span	131.64 ± 0.61		145.44 ± 0.94	

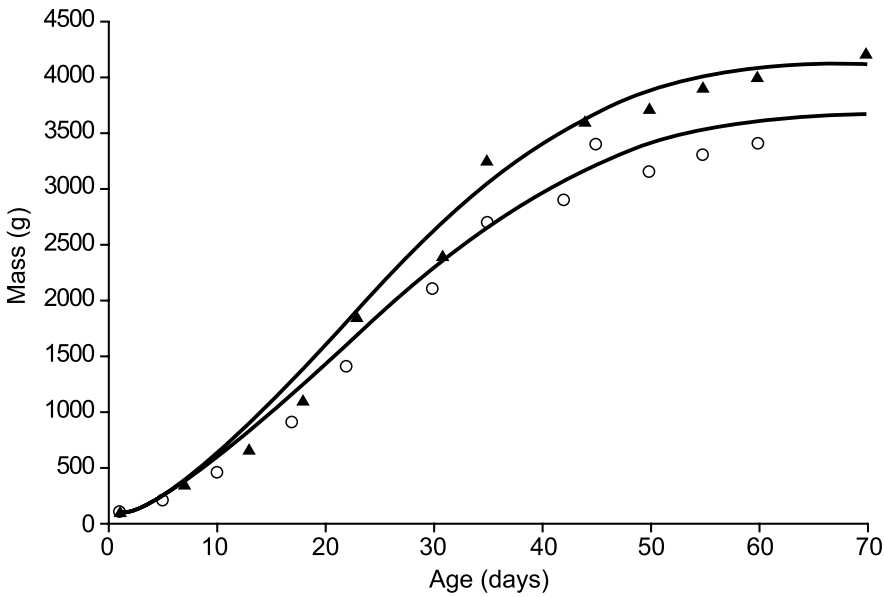

Figure 27. Growth curves of male (lower) and female (upper) nestling golden eagles, after Ellis (1979). Data from two Scottish birds are shown, a possible male (○) after (Gordon 1955) and a probable female (▲) after MacNally (1964). From Watson (1997), reproduced with kind permission of A&C Black.

4. SURVEYS OUTSIDE THE BREEDING SEASON

As golden eagles occupy their home ranges throughout the year, the population of resident adults and immatures could be surveyed outside the breeding season by foot searching as outlined above. Methods for censusing nomadic immatures have yet to be developed.