GU DE TO MANAGEMENT O' PEREGR NE FALCONS AT THE EYR E

Edited by
om J. Cade and James H. Enderso
he Peregrine ınd

and

Janet Linthicum
Santa Cruz Predatory ird Research Group

FRONTISPIECE

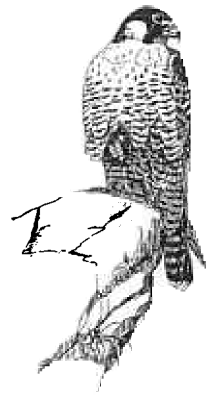
Scarlett with young on the U.S. Fidelity and Guaranty Building in Baltimore, MD.
Courtesy of T. Maechtle

This publication is made possible by a grant from Abdulla Masaood.

Cover art by Hans Peeters.
Additional art by John Gilardi, Rick Kline, and John Schmitt

GUIDE TO MANAGEMENT OF PEREGRINE FALCONS AT THE EYRIE

Edited by



Tom J. Cade and James H. Enderson

The Peregrine Fund
World Center for Birds of Prey
566 West Flying Hawk Lane
Boise, Idaho 83709
Phone: (208) 362-3716
Fax: (208) 362-2376
http: //www.peregrinefund.org
tpf@peregrinefund.org

and

Janet Linthicum

Santa Cruz Predatory Bird Research Group
Long Marine Lab
University of California, Santa Cruz
1156 High Street
Santa Cruz, California 95064
Phone: (408) 459-2466
Fax: (408) 459-3115
walton@cats.ucsc.edu

September 1996

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CONTRIBUTORS

John H. Barclay
Garcia and Associates
303 Potrero Street
Suite 29-101
Santa Cruz, California 95060

Tom J. Cade, Ph.D.
The Peregrine Fund
World Center for Birds of Prey
566 West Flying Hawk Lane
Boise, Idaho 83709

Nancy Clum, Ph.D.
The Peregrine Fund
World Center for Birds of Prey
566 West Flying Hawk Lane
Boise, Idaho 83709

James H. Enderson, Ph.D.
Department of Biology
The Colorado College
Colorado Springs, Colorado 80903

Peter Harrity
The Peregrine Fund
P.O. Box 39
Volcano, Hawai'i 96785

Willard Heck
The Peregrine Fund
World Center for Birds of Prey
566 West Flying Hawk Lane
Boise, Idaho 83709

William Heinrich
The Peregrine Fund
World Center for Birds of Prey
566 West Flying Hawk Lane
Boise, Idaho 83709

Janet Linthicum
Santa Cruz Predatory Bird Research Group
Long Marine Lab
University of California, Santa Cruz
1156 High Street
Santa Cruz, California 95064

Patrick Redig, DVM, Ph.D.
The Raptor Center at the University of Minnesota
College of Veterinary Medicine
1920 Fitch Avenue
St. Paul, Minnesota 55108

I. INTRODUCTION

Tom J. Cade

History of Recovery Effort

Captive-produced Peregrine Falcons *(Falco peregrinus)* were first released in the USA in 1974, when The Peregrine Fund hacked two youngsters from a campus building in New York State and fostered two nestlings into a wild eyrie in Colorado. By 1994, more than 4,600 Peregrines had been released in the USA by hacking, fostering, and cross-fostering in four regional programs: (1) by The Peregrine Fund in the East, (2) by The Raptor Center at the University of Minnesota in the Midwest and Great Lakes region, (3) by The Peregrine Fund in the Rocky Mountain states and Pacific Northwest, and (4) by the Santa Cruz Predatory Bird Research Group in the Pacific Coast states of Washington, Oregon, California, and Nevada. At the same time Canadian workers released over 1,500 young Peregrines in their country. As a consequence of all this work, by the mid-1990s there were about 160 pairs of falcons known to be again occupying eyries from the Mississippi River eastward where none had existed by the mid-1960s, about 120 pairs had been reintroduced in the Rocky Mountain states, and more than 150 pairs again existed in California, Oregon, and Washington. In addition, there has been substantial natural recovery of wild populations, particularly in Arizona, New Mexico, and southern Utah, where there are probably more than 250 occupied eyries, but also in other parts of the western USA. Overall, the known population in the USA south of Canada in 1994 exceeded 800 occupied eyries, with a conservative estimate of over 1,000 pairs (Enderson et al. 1995).

From the beginning, personnel from various state and federal agencies have been involved in the release work and other field aspects of the recovery program. Some, such as the Colorado Division of Wildlife, had major roles but most worked under the guidance of staff from The Peregrine Fund or one of the other primary Non-Government Organizations (NGOs). As need for the further release and reintroduction of captive-produced Peregrines and for other highly manipulative procedures comes to an end, NGO involvement becomes less important, and the relevant state and federal agencies should assume direct responsibility for the routine monitoring and management of Peregrine populations within their respective jurisdictions. The commitment of the NGO groups to the welfare of the Peregrine remains strong, however, and they will continue to be available for consultation and contractual work based on need.

Purpose of the Manual

In the spirit of cooperation that has always characterized the recovery effort for the Peregrine Falcon in North America, we offer this manual as a guide for those agency personnel and others who may need information about the techniques and procedures, and the biological and practical considerations, involved in the management and care of Peregrine Falcons at their eyries. It should be kept in mind when considering hands-on management that specific state and federal permits are required.

Some may be tempted to think that because it was once an "endangered species," the Peregrine Falcon will henceforth always require intensive management to maintain its numbers, but we do not agree. Intrusive and manipulative procedures will be needed mainly during the continuing build-up of breeding populations to accelerate the rate of growth and to correct problems that may be adversely affecting adult survival or reproductive success at specific eyries. Once the breeding populations have reached environmental carrying capacity, and the "serviceable breeding locations" (SBLs, Hunt 1988) are all as serviceable as they can be made, monitoring and some regulation of human activities around eyries are all the management that should be necessary. We should remember that for centuries Peregrines existed and occupied their traditional eyries year after year with no management at all and, indeed, often in the face of heavy human persecution. Wherever they are tolerated and left alone, and are not incidentally poisoned by chemical pollutants in the environment, Peregrines can survive and reproduce quite well in close association with human beings and their activities. This happy circumstance again prevails in many parts of the Peregrine's once depleted range.

II. MANAGEMENT GOALS

Tom J. Cade

There is one short-term goal, one essential long-term goal, and two other desirable long-term goals. The short-term goal is to complete the process of recovery and population increase. Various ends are attainable, depending on local or regional situations. Breeding populations, measured by eyrie occupancy, can be allowed to reach whatever number the current environmental carrying capacity will sustain, based on the number of SBLs available (Hunt 1988). Since we now have the ability to increase or decrease the carrying capacity of some environments by artificial means, e.g., by constructing or removing artificial eyries, within limits we can manipulate populations to whatever level is determined to be desirable. Each management jurisdiction will have to decide what its population goal should be.

Further population increase can occur passively by allowing the wild birds to increase by natural processes, or by manipulating the reproductive capacity and dispersal of the wild falcons to promote range expansion and eyrie occupancy. Methods for accomplishing the latter procedures are described in Chapter VII.

The essential long-term goal involves systematic inventories to assess population status, the safety, health, and reproductive capacity of established pairs, and the biological fitness (suitability) of their SBLs. These topics are dealt with in Chapters III and VI. The time frame for inventory work will vary depending on circumstance and need to know. In some situations surveys may be required annually during the breeding season, especially when there are perceived problems relating to survival or reproductive success. For example, a recent amendment to the Endangered Species Act requires five years of monitoring following the delisting of an endangered species. In other circumstances biennial, five-year, or ten-year survey intervals may provide sufficient information. In practice, it is likely that intensive, annual monitoring will occur for selected small or sample populations, while more extensive regional surveys will take place at longer intervals. The National British Peregrine Survey, which has occurred at ten-year intervals since 1962, has proved to be quite adequate for monitoring the recovery and expansion of this island population of Peregrines, which now numbers over 1,200 occupied eyries in Great Britain (Crick and Ratcliffe 1995).

The minimum kinds of information needed to determine population status and reproductive health are (1) eyrie occupancy and (2) number of young reaching fledgling or near-fledgling age. The presence or absence of adult falcons at known eyries should be determined during the egg-laying or incubation periods if possible, as this timing will give the best indication of the maximum number of pairs that settle to breed in a given population. Later surveys may miss pairs that fail during incubation. Sufficient time should be spent to determine whether a single bird or a pair is present. Ideally the eyries should be visited a second time when the young are about ready to fly, between five and six weeks post-hatching. In practice, if the young are to be banded when they are at the optimum age of three weeks, they may be counted as "fledged." Other desirable information includes clutch size, number of young hatched, causes of egg or nestling mortality, collection of eggshell fragments and addled eggs, and details on food type and delivery rates to the young. Since such data usually require climbing into the eyrie and are obtainable only through intensive work at a limited number of eyries, they are not likely to be collected during extensive surveys. Surveyors should record both the presence and apparent absence of Peregrines during surveys of potential nesting territories. This can help later surveys to address whether new pairs are real or result from increased search effort.

Another aspect of long-term monitoring involves the identification and resolution of specific local conflicts that may arise because Peregrines are predators. These conflicts may involve real or perceived threats to domesticated animals, especially to homing pigeons and other free-flying breeds, or to endangered forms of wildlife, especially to other birds such as Roseate Terns *(Sterna dougallii)*, Least Terns *(Sterna antillarum)*, and Piping Plovers *(Charadrius melodus)*. Although predation by Peregrines is not likely to be a significant factor in the region-wide control of prey numbers, statements to the contrary notwithstanding (e.g., Paine et al. 1990), locally a pair of Peregrines, or even a single resident bird, can have a significant impact on the number of prey when the falcons become specialists on one or two especially vulnerable species (Cade 1960, Nisbet 1992). Depending on the circumstances and the prey species in question, it may be necessary to remove the offending falcon or pair. Trapping and translocating a single migrant Peregrine that was causing problems at a ternery was easy and effective (Nisbet 1992), but the removal of a nesting pair of Peregrines is a more serious act because, in effect, it requires the destruction of an eyrie. Also, breeding birds may be far more motivated to return to the area than translocated migrants. Some artificially constructed eyries (towers) can be easily dismantled and moved, but once established on cliffs and buildings, Peregrines cannot be easily dissuaded from using them. It is worth noting that in Salt Lake City a pair of Peregrines nested on the old Hotel Utah from 1986 to 1990. When the building underwent exterior renovation in 1991, the falcons moved to a quarry two miles away and nested successfully there until the site was demolished in 1994. The falcons then moved back to the newly finished hotel building (now the Joseph Smith Memorial Building) and, after failing in 1994, nested successfully in 1995 (Walters 1995).

A second long-term goal related to monitoring and survey work is basic research on the Peregrine. Although research is often considered to be a separate activity from management, the two are, in fact, closely intertwined, and this has been especially true of work on the Peregrine Falcon during the past 25 years. On the one hand, informed management cannot proceed without basic biological information on the species to be managed, and on the other hand, the logistics and procedures involved in management can greatly aid basic research.

Although the Peregrine Falcon has become one of the most intensively studied birds of prey in the world, there are still many aspects of its population biology and ecology that are poorly understood and that, if known, could aid in the development of better management practices (see discussions in Cade et al. 1988). Some of the relevant subjects include: (1) better statistics on survival rates of different age classes, (2) factors determining dispersal and new eyrie establishment (acquisition of new SBLs or reoccupation of historical ones leading to increased breeding density or range expansion), (3) the relative size of the "surplus" non-breeding adult population to the breeding population and the environmental factors limiting the number of non-breeders, (4) age of first breeding in relation to

population density, (5) potential demographic importance of interference by supernumerary adults at eyries under saturated population conditions, (6) lifetime reproductive performance of females in relation to quality of SBL and/or quality of male as food provider, (7) how physical and biotic characteristics of nest site and territory influence survival of adults and young, (8) importance of prey abundance and availability to reproductive output at eyries, and (9) the influence of weather on reproduction.

Management authorities should consider integrating specific research projects to answer these and other major questions into their long-range protocols for the Peregrine. In some cases this work could be carried out by agency personnel; in others, the work could be contracted to universities or other research organizations with the relevant skills to do the job.

A final long-term goal could be to manage the Peregrine Falcon as a renewable and usable natural resource for falconry under regulations promulgated pursuant to provisions of the Migratory Bird Treaty Act and relevant state laws. The Peregrine has had a long history of use in falconry, and it is the species most closely identified with the sport worldwide. A regulated take of wild Peregrine Falcons for falconry is fully parallel in historical, social, and ethical justification to the take of waterfowl and game birds by gun hunters.

The biological justification for regulated take hinges on the concept of "harvestable surplus." Once a breeding population reaches the limit imposed by the number of SBLs in a given region, reproduction results in a surplus of birds above the number required to replace losses in the breeding population. The size of this surplus varies depending on the ratio between overall natality and mortality, the latter possibly related to environmental limitations outside the SBLs; but in well-adjusted, saturated populations the non-breeders can equal or exceed the adult breeding population (Newton 1988, Hunt 1988). A limited harvest established on a state by state basis would be a reasonable proposition in the near future.

If the Peregrine were regulated as a usable resource, avenues of federal and state funding for its management would open up that otherwise would not be available. In the long run such funding might prove to be more dependable and adequate than sources formerly derived from nongame and endangered species programs.

III. GENERAL METHODS

Discussion

The types of data desired and the status of the population determine the appropriate methods and level of intensity of research. Options range from protecting pairs which are at risk to direct disturbance, to large-scale monitoring or even manipulation to increase the number of breeding pairs. Simple monitoring of a regional population is desirable without hands-on management in most cases. Increasing populations or stable ones with high density probably do not warrant management to increase reproductive success or to redistribute young. If banding or other intrusive activities occur, they should only be undertaken as part of a large-scale and well-considered project with planned follow-up. Most management activities must be conducted by trained professionals and can be labor- and cost-intensive. In areas where Peregrines have not recovered fully, management may be warranted. It is probably also true that even with full recovery, Peregrines will remain fascinating to researchers, and such activities as banding, eggshell collecting, and pesticide analysis will proceed. Peregrines will continue to be valuable indicators of the environment into the future.

Survey and Sampling Techniques

James H. Enderson

Discovering Nesting Peregrines

A first goal of systematic survey work is usually a thorough count of territorial pairs in a given region so that occupancy rate and pair density can be followed in later years. Historical records of territories and even recent surveys are incomplete nearly everywhere. Some regions have yet to be searched at all, and the present increase in Peregrines may make earlier searches inadequate. Further, nesting pairs may tend to use poorer sites as more-suitable places become filled, as seen in Britain (Ratcliffe 1988). A reasonable estimation of the number of pairs in an area depends on a search of both known and potential sites.

LIGHT AIRCRAFT. Depending on the region, Peregrines tend to nest in predictable settings which can be mapped from light aircraft. In the western USA, searches from an altitude of 500 m, using maps of sufficient scale to show topography, have revealed how ground searches can be conducted. Fly a systematic pre-planned route to minimize flight time, and expect the discovery of unknown cliffs. Rate each site found on the basis of cliff height, prominence in the area, other desirable habitat features, and access on the ground (see Ellis 1982 for an example of how to evaluate habitat). In some areas, it may be possible to join aerial timber or fire surveys or Civil Air Patrol flights.

Where Peregrines nest on rocks such as some types of sandstone or granite, excrement may be conspicuous and may be seen from fixed-wing aircraft; however, lack of visible whitewash is not evidence of vacancy. Caution: low flight in fixed-wing aircraft has caused many wildlife survey fatalities because of turbulence and because conventional aircraft may stall, especially when turning.

Ultralight aircraft are slower, but are subject to the same hazards, and unfortunately the pilot must also be the observer. Airplanes are useful mainly for finding habitat and access routes.

HELICOPTERS. Helicopters have the disadvantage of near-prohibitive cost, but are useful in certain situations (White and Sherrod 1973). In Alaska's Seward Peninsula, investigators visited 33 Gyrfalcon *(Falco rusticolus)* sites in three days, a task otherwise impossible (Springer, pers. comm.). The high cost may be partially offset by the rate at which work can be completed if potential nesting sites are numerous. In Utah, researchers used a helicopter to place up to eight pairs of observers at overnight observation posts in rugged terrain; each pair was moved to a new post daily. In this way, coverage is increased because observers can often hike from drop-off points. Economy is increased when crews are ready for pickup, posts pre-determined (usually by using a fixed-wing aircraft), and the pilot thoroughly briefed on the flight schedule and route. GPS facilitates this work. Forested terrain works against helicopters because landing sites may be rare. Also, observation posts should not be more than 15-20 km apart; otherwise flight time is too great. Before leaving the helicopter at each drop-off point, the team signs out and indicates its location on a topo map or on GPS. Otherwise, pilots tend to lose people!

BOATS. Coastal searches are often unworkable in the surf, and overland routes may be few. In the Queen Charlotte Islands off mainland British Columbia, fast inflatable boats operated from sea-going fishing boats have worked well for near-shore surveys. Good weather is paramount. River systems are sometimes easy to search, but the craft used must match the river. Inquire locally. Most rivers are now run routinely. In remote regions, or on large rivers with many nesting sites, two craft must be used to survey both shorelines and to provide safety. For example, on the MacKenzie River in the Northwest Territories, investigators once missed several pairs, later found by another party. The river was too wide and too swift to search from a single canoe. Large rivers become too rough to negotiate when strong winds blow upstream; sit it out. Finally, fuel and power considerations may dictate downstream travel; return upstream by water is often impractical or impossible, and repeat trips may require ferrying upstream by aircraft.

If nesting habitat is extensive and nearly continuous, such as in Arizona's Grand Canyon, two large rafts and many observers can be used effectively. The first raft spaces observers near enough to each other that no pair is likely to be missed. Observers camp overnight, watching carefully at dusk and dawn, and are picked up in turn by a second boat the next morning. In the afternoon, the second boat meets the first at the lowest observation site, and the whole process is repeated farther downstream (see Brown et al. 1992).

This technique with two craft "leap-frogging" downstream is best where potential nesting habitat is essentially continuous. Far less certain is to float swift rivers, hoping to find sites as you pass by. Obviously, it is crucial for observers to stop and watch. Beware that people controlling the rafts often prefer not to stop; then good habitat goes unsearched. Lastly, boat motors and rushing water make it difficult to hear Peregrine vocalizations.

GROUND SURVEYS. Searches from roads and trails are basic. The main difficulty is that negative data (failure to see Peregrines) have limited value unless prolonged observations are made. The Dean of Peregrine watchers, J. J. Hickey, who first attempted a systematic analysis of Peregrine distribution (1942), once remarked, "Proving a site vacant is next to impossible, the observer may have arrived too late, or may have given up too soon." Some sites are easier to assess than others. For example, known sites can often be surveyed more easily than new ones. Camping at difficult locations is a good plan because falcons are active in the evening and in the morning.

Simple procedures such as using more than one observer, observing for adequate periods, using proper equipment, viewing from the best locations, and return visits are basic. A single observer may be lucky, especially if diligent, but 2-3 observers are much more likely to spot Peregrines in vast landscapes. D. Berger used the rule of thumb that five hours after dawn or before dusk is a minimum observation period. If no birds are seen after five hours of careful watching, observers can begin to wonder about a vacancy. Optical equipment should match the distance. Closer is usually better. Use lower power optics. Seldom is a spotting scope of greater than 15x justified for initial scanning. Lower power means less eye fatigue and wider field, the better to see a bird in flight. This is especially productive when the observer can get to a point maximizing the view of the cliff in the field of the instrument. A folding chair or a roll-up "power lounger" greatly increases observer endurance.

In Colorado, J. Craig and M. Robert have run very successful season-long surveys of potential nesting habitat. Observers worked in teams, usually two people, and they were free to fit their schedules around bad weather and other vagaries such as travel, rather than to follow a pre-determined schedule. Generally, teams included at least one experienced person from an earlier season.

There is no substitute for camping within ear-shot of a potential site. When the view is good, watching from below or across a canyon from a cliff works. Otherwise it is necessary to get on top at sites where this will not result in disturbance. Watching from on top is less boring, and binoculars are often not necessary. Schedule return visits to likely looking sites and do not waste time searching for other pairs within a couple of kilometers of an occupied site.

Overall, several factors work against the goal of obtaining complete data on Peregrine nesting density. The time for observation is limited to the window of the breeding season, and bad weather interrupts that period. Each year is a new case because of changes in site use and population size, and vacancy is not usually established. Additionally, potential Peregrine nesting sites are not easily identified because places of varying quality may be more or less continuous. Finally, the notion that sites acceptable to Peregrines in a region conform to a stereotype is misleading. Do not discount unusual or seemingly low-quality sites.

OTHER TECHNIQUES. It can be productive in large survey efforts to enlist the help of people likely to encounter nesting Peregrines, for example rock climbers, birders, kayakers, etc. If these people can be made aware that you are seeking information about nesting pairs, they can be a very useful source. Often, when a "new" territory is discovered by those surveying a region or state, locals will say the birds have been there awhile and they assumed the "authorities" knew about them.

In California, homing pigeons released from boats offshore were extremely useful in locating Peregrines (W. G. Hunt, pers. comm.). Although lack of response by Peregrines was inconclusive, many falcons that would have been difficult or impossible to detect from a boat in the chop were located in this way.

SURVEY SAMPLE SIZE. Long-term study of Peregrine nesting activity may require monitoring a sample of the total known territories. Sampling has been used in at least three states (California, Arizona, and New Mexico). D. Durland (in prep.) has used the Monte Carlo Method (Rohlf and Sokal 1981) to show the direct relationship between sample size and confidence in occupancy and reproductivity. He used data (G. Craig pers. comm.) from the 33 most-studied territories in Colorado, 1973-91. In this work Durland used a computer to choose 30 sets of territories of each sample size to show the increase in the accuracy of prediction with increasing sample size.

Results showed that when sample size was 24 territories or more, occupancy was not underestimated by more than about 5% in any sample. Actual occupancy was 91%. When sample size was 28 territories, no run underestimated occupancy by more than about 2%. Overestimation of occupancy did not occur above a sample size of 18 in 30 sets because all vacant sites were always included in every set.

Sample size to estimate productivity was found in a similar way, except 95% confidence intervals could be calculated for the mean fledging rate per territorial pair. When 30 runs were made for each sample size the 95% confidence limit was ±0.10 young per pair for samples of 24 territories, and the limit fell to ±0.05 young per pair with samples of 29 territories. The actual mean productivity was 1.60 young per pair. Generally, Durlan's preliminary results indicate sample sizes on the order of 25-30 territorial pairs provide close estimates of occupancy and reproductivity for a larger, actual population.

How does one choose the set of territories from which a sample is to be drawn? The choices can result in misleading conclusions if the sample does not represent the range of variation occurring in the overall population. Inclusion of sites not often used will cause a lower estimate of occupancy than a sample drawn from sites with long histories of steady use. Counts of fledging young may be lower if sites poorly located for viewing are chosen, or if highly productive eyries are under-represented in the sample. It should be remembered that in any regional population, a small number of highly productive pairs contribute a disproportionately large fraction of each annual cohort of young birds. While it is important to know the history of these "first class eyries," still the marginal sites are the ones likely to be abandoned first in the face of any pervasive adversity, and their histories may serve as the most easily detected early warning of an environmental problem. Workers might try to obtain a balance among the factors that characterize SBLs and qualify their data on that basis.

Adult Replacement

Biologists routinely study reproductive success as a measure of population health, and nowhere has the practice become so entrenched as with certain raptors. This emphasis stems from the ill-effects of organochlorine chemicals on reproduction, first discovered in the mid-1960s (Ratcliffe 1967, Hickey 1969). In Britain at that time, acute poisoning of adults was also seen, but adult survivorship was not often studied (see Ratcliffe 1993). Band recovery data were used to estimate mortality for Peregrines (Enderson 1969), but results were subject to unknown bias. Peregrines lend themselves to mortality studies because they show strong fidelity to a territory for life. This fidelity is not absolute; nevertheless, minimum mortality estimates can be obtained. Such information is important because population decline may not result from modest reproductive success if adult survivorship compensates (Newton 1979).

LEG BANDS. Substantial numbers of Peregrines in certain regions have been banded as wild nestlings or as the result of releases. Others have been banded during migration or as breeding adults at eyries. Some Peregrines wear alpha-numeric marker bands. If band numbers can be confirmed in succeeding seasons, a basic component of survivorship can be obtained. If this can be done at several territories over several years, a proportion of banded adults will be found missing in a subsequent year; birds either died, or were somewhere else. If the latter possibility is ignored, the ratio of instances where individuals failed to return the following year to those where they did return gives a maximum estimate of annual mortality rate (Mearns and Newton 1984). In that study, adults were trapped at the eyrie, banded, and retrapped in subsequent seasons — a Herculean feat made possible by the low cliffs used by Peregrines in Scotland. Mearns and Newton showed a small proportion of adults actually switched territories; when these were taken into account, turnover was only about 12% per year, probably explaining why that population grew at a time when reproductive success was little more than 1.0 young for all pairs on territory.

Unfortunately, trapping and re-trapping of a significant sample is simply not feasible in many regions (see Cade et al. 1988 for some other attempts). Bands can be read through a spotting scope, but this work is very tedious and may require observation from blinds. A scope such as a Questar with at least 120x magnification is generally needed. When an observer is on the nest ledge for other reasons, bands on females can sometimes be read through binoculars, but sample size will not likely be adequate. Bands on urban Peregrines on buildings can often be read through windows. When data from different years are pooled to increase sample size, annual variation in mortality is obscured.

FACIAL PATTERN. Adults have a pattern of malar stripe and white cheek patch that is sometimes unique to individuals. Coupled with other plumage characteristics, such as degree of barring on the ventral side, or overall melanism, individuals may be recognized with adequate confidence. Telephoto pictures can be made annually for later comparison, and turnover rate estimated as in the case of band observation (Enderson and Craig 1988). A 35 mm reflex camera with a motor winder mounted on a gun stock behind a spotting scope, or a 600 mm Novoflex system is useful. Adults defending young often come close enough to obtain good quality photos with this equipment. Quality photos do not always result, and all birds do not lend themselves to photography. A sample size less than about 15-20 territories over 3-4 years will likely prove inadequate for reliable estimates of turnover. Alternatively, facial features and other plumage characters of well-observed birds can be sketched for identification purposes (Nelson 1988). Figure 1 provides an example of sketches used by Jeff Sipple in Long Beach, California. Overall, these studies are practical regionally and on a long-term basis. Occasional data obtained during casual visits are useless.

VOICE PRINTS. The alarm vocalizations of individual falcons produce distinct patterns when analyzed for frequency and amplitude with a sonograph. The usefulness in distinguishing individuals defending eyries has yet to be shown. The major difficulty, aside from the high cost of the equipment, is to obtain quality recordings under uniform conditions. Factors such as wind, other noise, and

distance are inevitable. Preliminary results in the field have indicated some potential, but further research on this technique is needed (Beth Telford, M.S. Thesis, Boise State University).

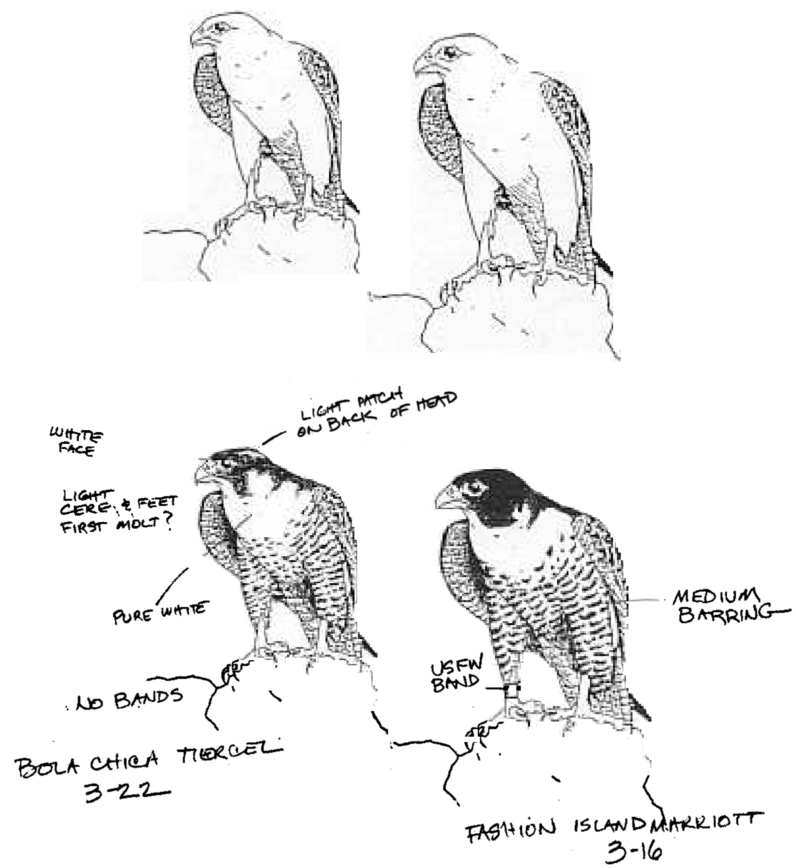


Figure 1. Outline sketch of Peregrines for noting details of individual appearance
Courtesy of Jeff Sipple.

Radio-Telemetry

Miniaturization of radio transmitters, made possible by transistors and development of hearing aid components, resulted in useful radio-beacons for birds in the late 1960s. Coupled with sensitive receivers, telemetry has revealed a great deal about the movements of raptors, and it has become indispensable in falconry.

Telemetry has been used to reveal the migration behavior of Peregrines and to study their movements in winter (Enderson et al. 1991, 1995). Few studies in the breeding period have been done, probably owing to difficulty of trapping adults, and to limitations of transmitter reception in rugged country. Telemetry has also been used to advantage in tracking falcons released by hacking, especially in the first critical weeks while the birds are developing their flying skills.

Most studies involve placing transmitters on a few Peregrines and then locating them periodically until the signal can no longer be detected. This happens when the transmitter fails, or the bird moves beyond reception range. Telemetry provides data only when signals are received and the source located. Location may be by triangulation resulting from a plot of compass bearings obtained simultaneously by two receivers. Error can be great in this method, especially where the receivers are near each other relative to the distance to the instrumented bird. Error can be minimized by wide-spacing of receivers, use of three receivers simultaneously, and by use of yagi antennas with many elements, or yagis coupled in pairs. In any case, estimates of error must be made. Computer programs such as Locate II allow confidence estimation for locations resulting from three or more simultaneous fixes on the transmitter.

A second technique is to use the receiver to guide the observer to the vicinity of the bird. This method may be difficult in roadless regions unless aircraft can be used. The advantage is that relatively precise locations are obtained.

Both methods are very labor intensive and yield relatively little data for the effort. Automated receiver stations coupled with a computer data base are not cost-effective in most situations involving Peregrines. Satellite tracking has recently become feasible for female Peregrines and has yielded some interesting results on intercontinental migratory movements. Satellite tracking requires special preparation and experience.

Two other telemetry problems are apparent with Peregrines. The wide-ranging movements of this species on the breeding territory, in winter, or in migration may exceed the reception range of transmitters small enough to be carried. Secondly, battery life beyond about 150 days is unlikely in a useful package. To some extent, range and battery duration are trade-offs, and performance differs by manufacturer. In practice, reception range does not often exceed 5 km when the transmitter is near the ground and the receiver antenna is hand-held. If the falcon is in flight the range may be 2-3 times greater. Reception from hills or mountain-tops may improve range, but 20 km is not likely to be exceeded often unless aircraft are used. In the latter case, range may be 40 km or more. In most situations, choose range over extended life.

All transmitters, even those of the same type, may differ greatly in performance. Several should be tested and the better ones selected. Other factors held constant, higher pulse rate and stronger signal imply shorter battery life. Recently, transmitters that operate on a duty-cycle have become available at modest extra cost. These are programmed by the supplier to operate in a pre-determined period

each day. Longer periods are available. A 12-hour cycle nearly doubles battery life; the transmitter works only in the daylight period.

Frequencies in the 138-151 MHz range were first used, but 165 MHz is said to encounter less extraneous interference, and 216 MHz enables use of a shorter transmitter antenna and a more portable receiver antenna. In some locations it may be necessary to check with researchers conducting other studies in the area to avoid duplication of frequencies.

Two transmitter mounting techniques are fairly safe. Three- to four-week-old nestlings can be equipped with a transmitter on a foot (leg) bewit, in the fashion used by falconers. Bewits should be tied closed with a single loop of cotton thread weak enough to break should the antenna become entangled. Eventually, cotton thread weakens, allowing the transmitter to be lost when no longer useful. This method has been used widely on hacked Peregrines, but the overall result in recovering fledgling young was not always successful owing to the inexperience of operators.

A second mounting technique, surely preferred for fully feathered birds, is to suture the transmitter to the base of one or two tail feathers, preferably with one or two attachment holes on each end of the radio. This technique should not be used on growing feathers. Dental floss is passed through the shaft of the feathers at the attachment points with the finest possible needle that will accept the waxed floss. Each end is passed around and below the feather, brought around on top, and knotted so that when the transmitter is tied to the feather, the load is displaced from the needle holes. The barbs of the vane must be separated at the exact level of the needle hole so that the barbs are not unduly displaced by the loop drawn tight. The transmitter is tied to each ligature; if two feathers are used, slack should be included, especially at the distal end, to allow for separation of feathers when the tail is spread in flight. The antenna may be sutured to the shaft along the feather, but this has not proven necessary if the antenna is thin Teflon-coated cable.

The satellite units require use of harnesses that mount the weight near the center of lift on the back. Experience is inadequate to draw conclusions on how safe they are on falcons.

Transmitters should be waterproof. Switches that activate the unit when a small magnet is removed have worked well, except transmitters placed in storage need to be checked to insure that all are inoperative. For Peregrines, units should not exceed 7-8 gm.

Two people are required to instrument a wild Peregrine. One holds the hooded bird chest down on a padded surface while the other attaches the unit. A card of thick paper can be slipped under the feathers to be used to isolate them from others. Surgical forceps are useful in pulling the fine needle through the hard feather shaft. Knots in waxed floss do not require gluing to secure them. Before the falcon is released, determine the exact frequency setting yielding maximum signal on <u>each</u> receiver to be used. Slight mis-setting may result in poor range. Also determine whether the transmitter is broadcasting on more than one setting.

Collect as many data as possible as soon as possible because transmitters may fail or be lost; for some analysis, avoid using fixes on the bird at very short intervals because they may not be independent. If the interval is too brief, the location of a fix is automatically related to the location of the preceding fix.

Figure 2. Technique for holding a young Peregrine while banding or attaching a leg-mounted transmitter.

When the bird is in flight, fixes every minute may clearly describe the general flight path. When signal strength varies noticeably beep to beep, the falcon may be in flight or otherwise active. Head sets with soft muffs greatly enhance detection of faint signals, especially in wind.

Several companies supply proven equipment. ATS, AVM, Custom Electronics, Telonics, and Wildlife Materials supply receivers, some based on the venerable designs of W. W. Cochran. ATS, L. L. Electronics, and Wildlife Materials make transmitters to order. The USFWS considers transmitters markers, and an explicit permit is required for their use.

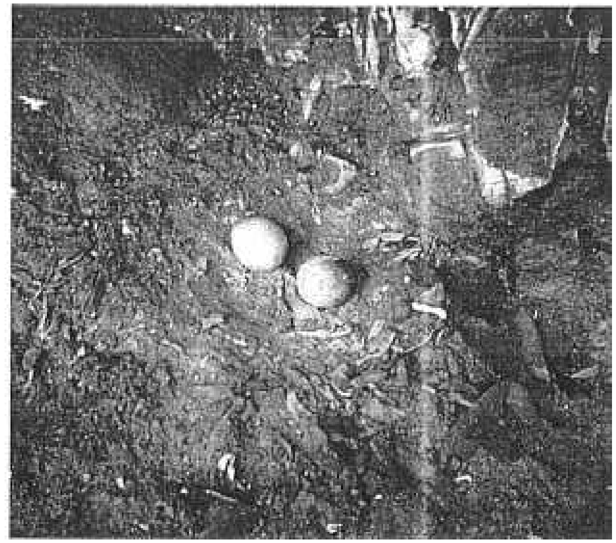


Figure 3. One dented and one intact addled egg in a failed coastal California eyrie.

Collection and Handling of Addled Eggs, Eggshells, and Prey Remains

Peregrine eggs, eggshell fragments, and prey remains have been subject to great attention for almost three decades. DDE causes sufficient eggshell thinning, in some cases, to result in egg breakage or failure to hatch. In theory, prey remains should indicate which prey species are used most, and chemical analysis should show which are the significant sources of DDE. Further, egg-content analysis should indicate the general level of DDE contamination in females at the time of yolk formation. Production of young should vary with thickness of eggshells (Fyfe et al. 1988). However, unless large samples can be obtained, data gathered in the field fail to show such correlations, owing to the great variation.

The confounding factors are many. Small prey birds, or large ones, may be under-represented for different reasons. Remains are mainly qualitative, not quantitative. Collection, and DDE analysis, of prey species commonly found as remains may not represent those actually eaten in the pre-laying season, especially if the prey species are migratory. Egg contents contain DDE residues from blood circulation generalized through the period in which ova enlarge, usually several weeks. But shell thickness is related to DDE in circulation in the few hours while the shell is formed. Hence, DDE in egg contents may not show a tight inverse correlation with shell thickness. If DDE level is low, shells may be normal, but some thick shells accompany DDE levels that would seemingly predict thin shells. DDE residues are usually fairly constant among eggs in a set, but shell thickness often shows great variation among individual eggs.

Hatchability of an egg depends on gas exchange properties of the shell, not just mechanical strength. No clear relationship has been shown among these variables, although it is also known that shell porosity is altered by DDE.

Thus far, the most widely accepted relationship is that only when eggshells in a population average more than about 17% thinner than normal will overall reproductive success be sufficiently lowered to predict inadequate recruitment. Normal is usually based on thickness of pre-1947 shells, laid prior to DDT use. Even then, shell thickness varied naturally among populations, and sampling error was undetermined. For example, 0.359 mm (with membrane) is the standard used for Rocky Mountain eggshells based on pre-1947 shells from the region, but 0.364 is used for the West Coast. Addled eggs or shell fragments picked up on ledges after fledging may not constitute an unbiased sample. It needs to be emphasized that so-called threshold values of eggshells 17 to 20% thinner than normal and DDE residues of 15-20 ppm in egg contents, which may signal population decline, are population averages, not values that can be applied to individual eggs. Most eggs that break or fail to hatch have much higher values than these averages, thus averages themselves are skewed toward the low side because many of the poorer quality eggs are never found.

Obviously, the odd prey remain, addled egg, or shell fragment gathered opportunistically is of essentially no value in revealing the well-being of Peregrines at given eyries, let alone at the population level. Nevertheless biologists like to collect things, and when lots of samples can be pooled over many years trends may appear.

PREY REMAINS. Feathers and body parts are often found on nest ledges, especially when the young are older than two weeks. Remains can often be found below the cliff or plucking perches. Expect samples to be biased for distinctive colors or patterns and for prey body weights easily carried by Peregrines. Feathers from many small passerines are very difficult to identify, even when complete museum collections are available. Pellets are a good source of feathers; unfortunately they are compacted and bent, greatly increasing the problem of identification. If prey identification is to be done in a serious way, individuals of all prey available to local pairs should be obtained, and representative feathers from all major body areas, and beak and feet should be fixed to a sheet of paper for reference.

EGGS. Addled eggs should be wrapped with aluminum foil rinsed with chromatographic grade acetone and placed in a screw cap jar cleansed in the same way. Keep eggs cool and freeze as soon as possible. Once frozen, eggs must remain frozen so that contents do not leak from shells that cracked during freezing. Later the contents should be placed in an acetone-rinsed vial with a foil lined cap of 50 ml capacity. Contents should be clearly labeled with freezer tape and permanent ink to avoid blurring from condensation. Rinse the intact, frozen, addled egg in warm water momentarily. Then cut the shell around the equator and remove the still-frozen contents intact. Rinse the shell halves gently and allow to dry completely. Egg contents should be shipped on ice, but various degrees of spoilage have been shown not to interfere with organochlorine analysis. It is far more important to prevent external contamination of the sample by residual chemicals adhering to dirty containers, labels, and wrappers.

Eggs gathered from nest ledges are somewhat dehydrated. Water loss concentrates the contents, including chemical residues, and unless correction is made back to fresh egg moisture level, erroneously high residue values result (Enderson et al. 1982). Freshly laid Peregrine eggs are about 85% moisture, and this value is used as the normal level for correction. Be sure to request that the analytical laboratory determine and report the moisture content of each egg. The concentration of each reported residue (wet weight) can then be corrected to fresh egg values by the equation:

$$\text{ppm (wet, 85\%)} = \text{ppm}_r \times \frac{(1-m_1)}{(1-m_2)}$$

where: ppm_r = ppm reported by lab

m_1 = fresh egg moisture (0.85)

m_2 = sample moisture reported by lab as a decimal

Example: lab reported 14.6 ppm DDE (wet basis) and percent moisture of sample = 64%; hence ppm (fresh basis, wet wt.) =

$$14.6 \times \frac{1-0.85}{1-0.64} = 6$$

Laboratories usually report residue values on a wet weight basis, but the reported value must be corrected to take into account desiccation. Without correction, wet weight residue values are quite meaningless. In the extreme, a thoroughly dried content sample would yield residue values nearly six times greater than had no water loss occurred. Alternatively, the residue can be reported on a lipid weight and/or a dry weight basis, and this method is more reliable for desiccated samples. Residues are usually reported in parts per million (ppm). Mg/kg or ug/g are expressions of ppm.

EGGSHELLS. Shell thickness may be measured directly, or inferred by the ratio of the weight of the whole shell to its size. The latter is the basis of Ratcliffe's Index, named for Derek Ratcliffe (1967), the astute Englishman who discovered pesticide-induced shell thinning. The index (without units) results when the weight (mg) of the dried shell, as encountered in museum collections, is divided by the product of the length (mm) times the width (mm). Normal Peregrine eggs yield a result of around 1.85. The index shows a fairly tight correlation with actual thickness. The index can be easily obtained for eggs picked up in the field if length and width are measured with a vernier calipers before the egg is opened. Later the dry weight of the entire clean shell can be ascertained. The index offers no advantage over direct measurement, except that it is perhaps a safer technique when valuable museum eggs are involved. The condition of shell fragments cannot, of course, be measured by this means.

Direct measurements can be made mechanically or optically. Dial micrometers, accurate to 0.005 mm, equipped with a piston long enough to reach through the blow-hole of the intact egg shell all the way to the opposite side of the equator, are useful for museum shells. The shell rests on the platform of the micrometer holder, and the spring-loaded piston measures the minimum distance occupied by the shell between the piston and platform. The tip of the piston, which presses against the interior of the shell, should be about 2 mm in diameter and convex with a similar radius. Error is introduced if both sides of the shell are not clean. Fragments can easily be measured by this means.

Optic measurement can be done with an ordinary compound microscope using a 5x ocular lens and a 10x objective lens. The ocular is fitted with a clear disc finely etched with a scale of units and tens. The scale is calibrated by means of a stage "micrometer," which is a thick glass slide, etched in gradations of 0.1 and 0.01 mm. The stage micrometer is viewed with normal back-light through the ocular, and the ocular scale is super-imposed on the stage scale. You must determine the value of each lesser gradation on the ocular scale which will alone be used to measure eggshell pieces. A typical result is that 10 of the smallest units on the ocular scale subtend 0.086 mm on the stage scale; therefore, one unit on the ocular equals 0.0086 mm. Remove the stage scale.

Measure chips taken at three places around the equator of the shell. Each chip is set vertically in a small modeling clay cone on an ordinary glass microscope slide. Overhead light from a small high-intensity goose-necked lamp provides adequate illumination. The edge of the shell is brought into focus and aligned with the ocular scale by manually shaping the clay holding the fragment. Count the total small units in the ocular between the outside and inside edges of the shell. For example, a normal shell might include 43 units, membrane included. The measurement would be 43 x 0.0086 mm = 0.370 mm. Always measure freshly broken surfaces and try to use pieces with the membranes still tightly adhered. Membranes are often found shrunken and detached from dried shells. If membranes are loose or missing, measure the shell alone and add 0.079 mm, an average value for the membranes obtained by optical measurement from many intact shells from captive-laid eggs (Burnham et al. 1984).

The optical method has the advantage of enabling the technician to see exactly what is measured. Dirt on the outside, or remnants of egg contents on the inside can be discounted. Tiny fragments can be measured if they can be stuck vertically on the clay, but accuracy can be sacrificed if the shell fragment is not truly vertical to the plane of view.

Another method, employed at the Western Foundation of Vertebrate Zoology, using the highly accurate Federal Model 35 Bench Comparator Thickness Gauge has yielded an average membrane thickness of 0.063 mm by comparing whole eggshells (museum specimens) with and without membranes (L. Kiff pers. comm.)

Fragments may be obtained by screening nest-ledge substrate after the young have fledged. Use a piece of one-eighth inch mesh hardware cloth as a sieve. Fragments from the current breeding season usually retain pigment, but weathering quickly causes pigment to fade. Fragments may be from several eggs. Measure 10-15 fragments to get a general value for the sample. Peregrine eggs are variable in pigment, and even single eggs show a mosaic of pigment; thus, attempts to sort out fragments from single eggs are not reliable. Even when a correction for membrane thickness is added to measurements of fragments, measurements from fragments

may be incomparable to those from intact eggshells owing to mechanical abrasion and weathering of surfaces of small chips.

Shell thickness is usually measured in millimeters to three decimal places. The third decimal place is surely not significant. Researchers are mainly interested in the general level of shell thinning revealed in adequate samples. Experience has shown that trends in thickness can be shown only over several years, or even decades, owing perhaps to the slow change of levels of DDE in the environment. Only when large samples of shells are thinner than 17% of normal might DDE-caused reproductive difficulty be suspected at a population level. Immigration or low adult mortality may offset reduced productivity and sustain the population. Thin eggshells should serve the purpose of putting Peregrine biologists on the alert.

Banding

William Heinrich

Since 1975, thousands of Peregrines have been banded throughout the world. At least 7,000 young Peregrines have been banded in North America, including over 4,600 captive-produced Peregrines released wearing USFWS bands and most some kind of alpha-numeric or color-coded band. Figures from the federal banding lab show that 22,035 Peregrines, including migrants, were banded between 1955 and 1991, and 1,529 recoveries had been reported. The encounter figures also include birds banded prior to 1955, but those numbers are insignificant (D. Bystrak, pers. comm.). The number of encounters is about seven percent of those banded, or about one in every 14.4 Peregrines banded. Many of these recoveries were of migrant birds caught in annual trapping programs. Significant numbers of Peregrines have also been banded in Canada, Greenland, and more recently, Central and South America.

Banding data have given us an understanding of Peregrine migration, natal dispersal, and longevity. The usefulness of banding increases when a large number of birds can be banded in a short time. Examples include birds being released from captive propagation programs, birds trapped on migration in areas where they concentrate, and areas where large numbers of breeding birds are accessible.

In view of the current increasing population status of the Peregrine and the tremendous amount of knowledge gained about the species through the years, occasional banding of Peregrines without intensive follow up work is probably ineffective and unjustified. The potential risk to climbers at eyries and to the Peregrines, not to mention the time and expense involved, should discourage casual banding because little useful data will result.

Banding requires careful data processing, and federal and state permits must be obtained. Banding should be done by experienced raptor banders. Approximate age of the young should be determined before attempts are made to access the eyrie (see Chapter V, a photographic guide to aging nestling Peregrines). Banding should take place only when the young are between 21 and 35 days of age. Prior to 21 days it is difficult to determine sex. The wrong-sized band could be placed on the young falcon's leg, or it might slip off. Attempts to band nestlings over 35 days old may result in premature departure from the eyrie. Whenever there is any doubt about the sex, use a female band only. For *anatum* Peregrines, USFWS lock-on #6 bands should be used for males and lock-on # 7A bands for females.

Careful planning should take place before banding. All band numbers should be pre-recorded. This practice eliminates recording during the actual banding process. Ideally, two people should be involved, one to hold the young carefully while the other places the band on the correct leg, depending on the current protocol being followed. Peregrines are especially delicate at this age, and it is easy to break bones, cause dislocations, and damage developing feathers if the birds are not handled properly. Do not allow the young to hang upside down, be held by legs alone, or to overheat in a pack or sack. Banders should move very slowly when attempting to pick up young. Rapid movements often frighten older chicks, causing them to take a defensive posture lying on their backs with their feet extended, ready to grab the bander or even other siblings if they get close. Young should be held with both hands clasping the wings next to the body just below the head and neck with the front of the bird facing away from the holder and toward the bander. Do not hold the bird so tightly that breathing is impaired. The chest should be allowed to expand and contract freely.

A pair of large needle-nosed pliers and/or a pair of medium to large channel-lock pliers work best to open and close the lock-on bands. Many color bands require a pop rivet tool. Care should be taken to see that the band remains round to prevent undue pressure on the leg and that the seams are even to prevent sharp edges (see North American Bird Banding Manual, available from the USFWS). After each bird is banded, it should be gently placed away from the others facing into the back of the nest ledge or box. This procedure helps to prevent the young from attempting to fly prematurely. In cases where only one bander is present, a standard-size Ace medical bandage can be used to secure the bird in the same position as it would be held. Do not place the bandage tightly. A falconer's hood may also be used to keep the bird quiet.

Banding is best done in the morning during moderate weather conditions. Banding should be avoided during extremes of temperature to preclude the chance of stress to adults or young. Minimum time should be spent at the site during the banding process. Banding at many cliff sites is not recommended because of the time involved in getting into eyries and the potential danger to both climbers and birds. Only very experienced climbers and banders should be involved in banding young in even what appear to be easily accessible cliff eyries. Banding at eyries on man-made structures may be easy (towers) or difficult (bridges), depending on location.

In addition to the USFWS bands (some of which are colored), color bands are used on the opposite leg in most regions. Banders should be aware of current protocols in their areas and obtain additional bands well ahead of time. The National Park Service has developed a satisfactory marker band under the direction of M. Britton. Special permission must be obtained from the Federal Bird Banding Laboratory to use these markers.

Figure 4. Banded adult with tail-mount transmitter ready to be unhooded and released, held around legs and upper tail *Courtesy of David Jesus.*

Observing Breeding Behavior

Janet Linthicum

It is important that suspected nesting areas be adequately checked, especially early in the breeding season. In areas where reproductive success is being monitored, all territories should be checked at least twice during the nesting season. More frequent visits may be necessary to determine exact timing or outcomes if precise information is needed, for example in manipulation efforts. Visits are usually most productive if they occur at dawn or dusk, because behaviors such as food and nest exchanges are highly likely to occur at these times. During other parts of the day, more time may be required at a site to get the same information.

All sites should be documented in such a way that a later researcher can easily find them. Directions to the site, photographs, and sketches are all extremely helpful, and should be put on file (confidentially) in case the current researcher is not available for future survey work.

Timing

INCUBATION. Mid-March (April or later in northern areas or high elevations). Determine whether the territory is occupied by one or two falcons. Record presence of falcons, age, courtship, incubation behavior, nest location, band status, etc. If no falcons are seen, the site should be visited again, and possible alternate sites checked, as Peregrines can be very hard to detect during incubation. First-time layers often lay eggs later than expected for their region. Incubation lasts approximately 33 days.

NESTLINGS. Late April to June in temperate latitudes. Determine whether adults are still attending the nest where eggs were laid, and whether young have hatched. If there is nest failure, the pair may have relocated and laid another clutch on a different ledge. If it is possible to see into the nest from the observation point, record the number of young.

FLEDGING. Late May to mid-August. Depending on previous nest chronology, young should be ready to fly near this time, roughly 40 days after hatching. Recycling after egg failure can cause nest departure to be delayed from the "expected" date by a month or more. Record number and sex of fledged or near-fledged young. At sites where the observer cannot see into the nest, young must be counted after fledging. The resulting number should be considered a minimum, as some young could go undetected or have died or dispersed before the visit.

Behavior

This information is intended to help in determining reproductive status at eyries where the observer cannot see into the nest, and so must ascertain status based on behavior. It is written primarily for those watching nests intensively, for example if manipulation is planned, but may also be useful for individuals with limited experience. It is helpful if observers use this information to describe vocalizations and behaviors in a standardized way. For example, reports of Peregrines "peeping" or "calling" do not convey useful information to the reader. Detailed descriptions of behavior can be found in Cramp and Simmons (1980), Sherrod (1983), and Ratcliffe (1993).

COURTSHIP. BOWING. A general display used in many situations, especially as part of courtship.

MALE OR FEMALE LEDGE DISPLAY. The falcon stands over the nest depression (scrape), leaning forward (bowing) and "ee-chupping." The male often stares at the female during a male ledge display. Ledge displays are often accompanied by:

SCRAPING. Either bird can do this. The falcon runs its breast through the substrate or nest depression, pushing out with its legs behind. The bird is forming the nest cup (scrape), but this is also part of courtship. Scrapes may be made at several potential ledges before one is finally chosen for laying.

MUTUAL LEDGE DISPLAY. Often this is precipitated by a male or female ledge display. The other bird joins the first on the ledge and both bow and "ee-chup" over the scrape, sometimes touching bills. This can also happen outside the eyrie.

FOOD TRANSFER. The male offers food to the female by approaching her or standing near, with food in talons or beak, "ee-chupping." The female takes the food from the male, usually "ee-chupping" or wailing. This can happen in the air or perched. The male often signals the female that he has food by wailing as he approaches the cliff.

LANDING DISPLAY AND HITCH-WING POSTURE. (male). A pre-copulatory display in which "shoulders" are held high, as if in a shrug, and male often prances as if on tip-toe.

COPULATION. The female leans forward and moves her tail to one side. The male rests on his tarsi on her back, flapping his wings, and presses his tail underneath the female's. Copulations are usually accompanied by wailing on the female's part, and chittering or "ee-chupping" by the male. When the male departs, the female usually "ee-chups" a few times, and often rouses (shakes her feathers).

OTHER BEHAVIORS. CACHING. Peregrines sometimes store uneaten food for later retrieval. They usually have several favorite cache spots on the cliff or elsewhere in the territory.

CASTING. The falcon hangs its head and wags it from side to side with mouth open. Eventually a pellet (casting) of non-digestible material is expelled.

VOCALIZATIONS. EE-CHUP. A repetitious, staccato "ee-chup ee-chup ee-chup" sound. Males have a higher-pitched "eechip." Variations include a slower "chip chip chip," usually during ledge displays and while feeding young. "Ee-chup" usually implies social recognition, but a very similar sound, louder and more staccato, is given as a response to vagrant raptors, usually Peregrines.

CACKING. Very loud "cack cack cack" — A response to disturbance, either a raptor or other animal (including the observer) too near the eyrie.

WAILING. A long, slow, ascending "waaaaaa waaaaaa waaaaa." Sometimes connotes hunger, but also used in a variety of circumstances. Youngsters have a more insistent variation of this call, which is often referred to as hunger screaming.

CHITTERING. Like "ee-chupping" but quicker and less defined. Usually used by birds in proximity, often when one bird is being made uncomfortable by some aspect of the interaction, or during play by fledglings.

Behavioral Chronology

PRE-LAYING. Both birds are visible for extended periods outside the nest. This can happen when there is a partial clutch.

PAIR FLYING. Both birds engage in high speed aerobatic displays, with no apparent hunting or territoriality involved. This indicates that the female is probably not lethargic with eggs yet. Sometimes males engage in spectacular flight displays while the female watches.

TANDEM HUNTING. Self-explanatory. Again, the female is probably not laying eggs yet.

LEDGE DISPLAYS. See above. **NOTE:** Sometimes the falcons concentrate courtship in one spot, then suddenly lay eggs in a different, often more cryptic location. If both birds are suddenly no longer seen together, or activity at the expected nest subsides, suspect that the birds have moved and that they might have eggs.

FOOD TRANSFERS. These occur, male to female, in the air or at a perch throughout the nesting season. As incubation approaches, concentrate on the male after the transfer. He is often the key to incubation as described later.

COPULATION. Before and during egg laying, Peregrines copulate frequently. When the clutch is complete they rarely copulate.

EGG-LAYING. LETHARGY. Just before and during the period of egg laying (approximately eight days for four eggs) the female becomes lethargic. She can look "dumpy," including fluffed-up feathers while perched, hanging her vent feathers (the feathers in front of the cloaca, underneath the tail) to an unusual degree, leaning slightly forward while perched, waddling when walking, dozing with one or both eyes closed for long periods, and generally remaining near the nest and being inactive. She might also spend considerable amounts of time in the nest by herself. After laying an egg, she may have periods of being more active, but lethargy is a general demeanor to note. Those without much previous experience with Peregrines should be aware it is comparative and subjective.

PARTIAL CLUTCH. The falcons usually begin incubating after the second or third egg, even if a fourth is to be laid. Before incubation starts, they often "guard" the eggs, standing in the nest or within sight of the eggs. This is an indication that at least something is in there. Again, the male is the key. After a food transfer or nest exchange, watch the male. If he enters the nest for a while (even a long while) then comes out and perches out of the nest while the female also remains outside, you are fairly safe in assuming that full incubation has not started.

INCUBATION. During the normal course of incubation, one of the adults is nearly always on the nest. Exceptions are during disturbance, for short periods on particularly warm days, or for a few minutes during food exchanges. The female does the majority of incubation. The male brings food to her several times daily, or sometimes simply relieves her and takes a turn on the eggs while the female eats, preens, and relaxes. When she returns to the nest to relieve the male, he usually appears on the ledge when she disappears; an unaware observer may think only one bird was involved in a brief visit to the ledge. A common mistake is failure to realize that the bird leaving a spot is not the same bird that just arrived there (i.e., nest exchange as opposed to just perching briefly). This is why it is important to be able to distinguish sexes. During food exchanges the male arrives with food, often wailing or ee-chupping and passing in front of the eyrie where the female can see him. She then exits the eyrie and takes the food, either at a perch or in the air. This exchange gives a good opportunity for locating the nest. The best way to determine that incubation is occurring is to train your attention intently on the eyrie and be

certain that the attending falcon remains in the nest until relieved by the other adult. This can be very tedious, but is worth the trouble because otherwise it is possible to see a lot of behavior, and yet not determine what is happening. Observation of several sequences in which an adult attends until a nest exchange occurs indicates that incubation is underway.

If the observer is unable to see the eyrie opening, other behaviors may be helpful. For example, voluminous excretion has been used to determine incubation in coastal California, where the observer sometimes cannot see the cliff face that the eyrie is on. When a nest exchange is occurring (e.g., the male brings in food and disappears toward the nest, and soon thereafter the female appears coming from that area) watch the female. After she perches, she soon slowly leans forward and emits a large quantity of excreta. This can also occur while flying. This behavior indicates that the falcon has been unable to defecate for a prolonged time (i.e., has been incubating). Also watch for rousing (shaking of all feathers in a relaxing manner), stretching, and preening intensively. All of these are normal behaviors, but tend to be exaggerated after a stint of incubation.

EGG FAILURE. Some pairs lose their eggs to breakage, weather, or other factors. If this occurs while laying is still underway, they may relocate to a different ledge and attempt to complete the clutch there. If the clutch has been completed and incubation is underway, and the eggs are then lost, the first egg of the second clutch is usually laid approximately fourteen days later if recycling occurs. Sometimes, falcons exhibit the "lost look" after failure, returning to the scrape repeatedly but not staying, and wailing frequently. The falcons usually change ledges after failure, sometimes quite a distance away (possibly an alternate cliff), so do not assume they have given up if they are not in the usual places. Re-nesting may occasionally occur after loss of a young brood, or even after a second set of eggs is lost.

YOUNG. As hatching approaches, the adults often become more aggressive. During the early nestling stages the young require almost constant brooding, which can be hard to distinguish from incubation. The main difference is that after a food exchange, the female takes the prey into the nest rather than eating outside (she may pluck it before entering the eyrie). During the early nestling stage most females do the majority of feeding. Males provide food, and may brood young during the female's absence.

After approximately two weeks, depending on ambient temperature and number of chicks, the young no longer need constant brooding. Therefore, both adults are often outside the nest for extended periods. This is easily mistaken for nest failure. Depending on size of prey and number of young, the nest may only be visited a few times a day by the adults. Clues to presence of young include continued territoriality by adults, absence of courtship behavior, frequent hunting attempts, sometimes hunger screams of young, and, of course, prey deliveries. As the young age, they begin eating on their own, and sometimes a prey delivery is extremely brief. Also, late in the nestling stage the female hunts, and the male as well as the female feeds young. Some males are absent from the immediate nest area most of the day, either hunting or perched out of sight, except when delivering prey. Clues to failure include either adult eating full meals without delivering food to the eyrie, decreased territoriality and presence at the cliff or resumed courtship behavior if recycling is occurring, and frequent wailing.

DISTURBANCE. Observers should find an observation site with optimal visibility, but where their presence does not interfere with normal falcon behavior. In some cases distant locations can provide a better overall view of the cliff and falcons coming and going. However, those with little observation experience with Peregrines may find them difficult to spot from a distance, and vocalizations can be very helpful. The falcons respond more to an observer above the nest than to one below or across from it. Cacking birds are sufficiently disturbed that observers should retreat and find another location immediately. Signs of lower-level disturbance can include soaring above the cliff silently (watching the observer), perching where they can watch the observer rather than engaging in normal behavior, and sometimes displacement aggression such as assaulting a cormorant, gull, or other large bird in the cliff vicinity. Generally, if a falcon seems to be watching the observer(s), consider retreating to a more distant location. Even if the birds are not disturbed, they may be less inclined to engage in the behavior the observer is there to see if they are distracted. Before beginning observations, find a spot from which to observe for extended periods without becoming uncomfortable, distracted, or eager to depart.

ADDITIONAL INFORMATION. Ideally, observers should learn to distinguish the male from the female, preferably while both are still visible simultaneously. The best indication of sex is size, females being larger than males. However, it can be extremely difficult to sex a single bird on this basis, and experienced observers often err. If there are identifying aspects of individual falcons, they can be very helpful once incubation has begun and the observer rarely sees both birds at once. In many pairs, the female looks darker overall on the breast and farther up toward the neck, and may have a darker, slightly brownish tinge to the back. The male looks more white on the breast from a distance, and more silver on the back and especially in the rump area in flight. Some males are vividly orange around the cere (fleshy portion of beak) and feet (as opposed to bright yellow or yellowish-orange). There is much variation among individuals, so get to know the pair if possible. Male voices are higher-pitched, and in flight their wings are more narrow with sharper ends. Peregrines molt their flight feathers during the breeding season, with females usually beginning to molt before males. Differences in the gaps in wings and tail can be helpful in distinguishing individuals during a given day's observation.

Occasionally, one of the pair is a yearling. Yearlings have bleached considerably during the year and may appear "blond" rather than brown, and could be confused with an adult at a distance. A good method of checking is to note whether the marks on the breast are vertical streaks or horizontal bars. Occasionally, one may encounter a yearling that has already molted partially by its first spring, or a two-year-old that molted incompletely its first year. These birds may breed successfully, although many do not.

Recently fledged young are brown with vertical streaks on the front, and may appear somewhat larger than adults of the same sex, because their flight feathers are slightly longer. Their wing tips in flight are more rounded than those of adults. They often flap their wings while perched (exercise), land clumsily, and engage in mock combat, tumbling and playing together in the air. When an adult is in view, they hunger-scream, and often chase the adults. In begging while flying, they sometimes appear to flap their wings quickly (flutter). Seen from above, powder

down may cause young in flight to appear bluish, leading to confusion with adults; however young of the year have conspicuous light tips on the tail feathers.

For future reference, notes should contain a description of the adults, especially of bands (color and leg) and any unusual characteristics if possible. This can help future observers to determine longevity, continued occupancy, etc. Some Peregrines have alpha-numeric bands in addition to U. S. Fish and Wildlife Service bands. These bands usually have two characters, numbers or letters or both, that are meant to be read at a distance. When one of these bands is read, it is necessary to draw the band as it appears on the leg for reporting purposes. This is because there are several combinations of the same characters in existence, and the arrangement of the characters on the band is important for identifying it. For example, characters can be horizontal and/or vertical, and may have a line between them. Some bands are more than one color.

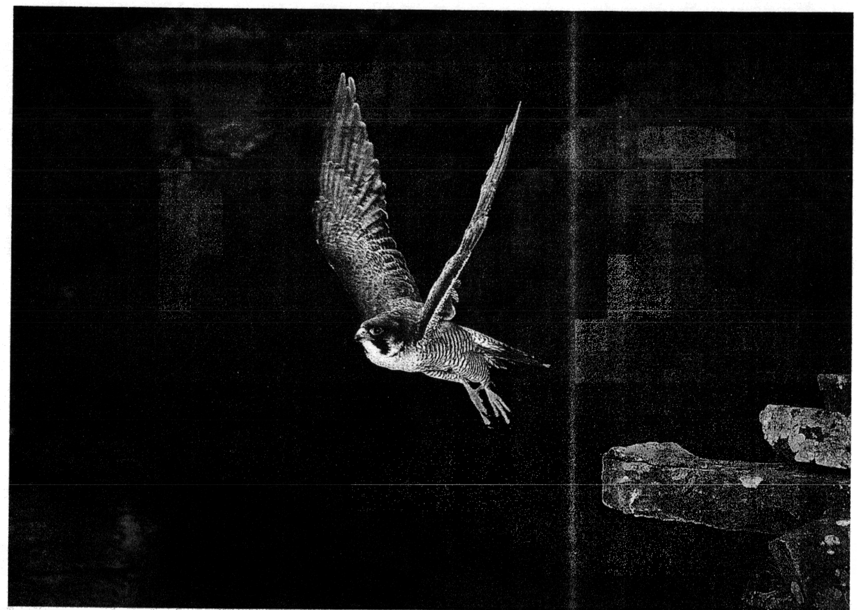


Figure 5. Adult female leaving perch
Courtesy of Rick Kline

IV. COLLECTING TISSUE SAMPLES FOR LABORATORY ANALYSIS

Patrick Redig

This chapter discusses techniques for collection and handling of biological samples from falcons and other raptors in the field, specifically, procedures for collection of blood samples, microbiological samples, and tissue biopsies. These samples can be useful for a variety of purposes. These include pesticide analysis, parasitology, genetics, nutritional analysis, etc. Interpretation of samples may be significantly affected by the skill with which the sample was taken as well as the likelihood of contamination. Proper equipment, proper technique, and knowledge of the appropriate sample for the desired results are required. Subsequent handling of the material all the way to the laboratory is also critically important.

Blood Sample Collection

MATERIALS AND EQUIPMENT. For most purposes, blood samples are taken with a 1 cc tuberculin syringe (Monoject, Division of Sherwood Medical, St. Louis, MO 63103) or a larger 3, 6, or 12 cc syringe. Additionally, a small squeeze bottle containing 70% ethanol or isopropyl (rubbing) alcohol, some cotton balls, small gauze sponges, and test tubes for decanting the blood are required. Needles are sized according to the volume of the sample and the size of the bird from which it is collected. Anticoagulants such as heparin and EDTA are required for some samples (see Table 1). Routine hematology samples and volumes of up to 1 cc can be easily collected with a 25 gauge needle. Larger volumes should be collected with 21, 22, or 23 gauge needles. Raptors weighing less than 150 grams should not be cannulated with needles larger than 23 gauge. Raptors of 1 kg or more tolerate the use of the larger 21 and 22 gauge needles. Larger needles cause unacceptable post-puncture hemorrhage.

Table 1 gives a summary of purposes for which blood may be drawn, along with recommendations for equipment and handling. Blood drawn for routine hematology only (PCV, TP, and film) does not require use of an anticoagulant. In fact, contact with heparin will render cells in blood films unfit for microscopic evaluation. Since clotting naturally occurs without an anticoagulant, the films must be prepared within 30 seconds or so of the time of sampling. Satisfactory blood films can be prepared from blood collected in EDTA so long as contact time with the anticoagulant does not exceed about six to eight hours.

When samples are collected for plasma harvest, heparin is generally the preferred anticoagulant. To heparinize a syringe, draw a sufficient amount of heparin into the barrel to wet the sides of the syringe, then express it all back into the bottle, leaving only a small amount in the dead space of the syringe. If blood films are to be prepared from a sample drawn into heparin in this manner, use the blood that is still in the needle at the completion of drawing and which theoretically should not have contacted the heparin.

SAMPLING. Blood may be taken from four sites (Fig. 6), including (1) the cutaneous ulnar vein on the ventral side of the elbow, (2) the brachial (or basilic) vein on the ventral humerus, (3) the jugular (right side only), or (4) the medial tarsal

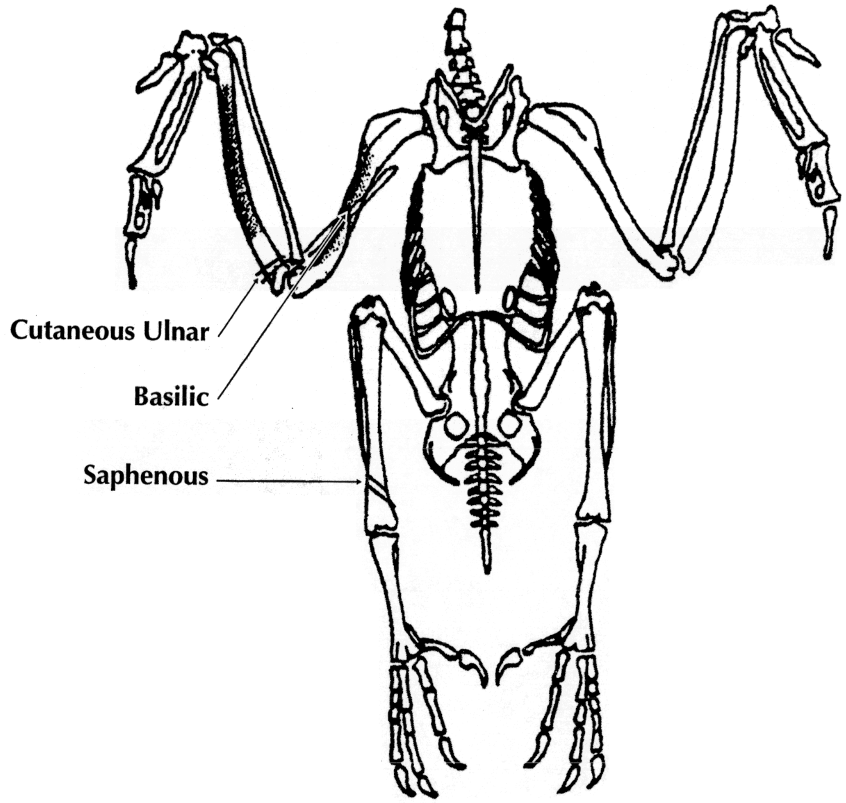


Figure 6. Falcon skeleton showing three of the four sites for drawing blood
Courtesy of The Raptor Center, University of Minnesota.

or saphenous vein, just above the hock joint. The latter is more useful in waterfowl than in raptors or other birds.

A syringe is heparinized if a plasma sample is needed for further analysis, because serum yields from avian plasma are very low. For simple hematocrit and total plasma solids, the tuberculin syringe is not heparinized. For collecting blood from the brachial vein, the bird is restrained on its back, the area of the midsection of the ventral humerus is lightly dampened with alcohol, and the feathers cleared away. The alcohol makes the skin transparent and the vein obvious. Since the humerus angles downward from its attachment to the shoulder toward the table surface, access to the vein is facilitated by bending the needle to match, bevel facing up. Insertion involves aligning the needle with the longitudinal axis of the vein and approaching directly on top of the vein. Entry to the lumen of the vein is a two-step process: the first is penetration of the skin; after this, forward pressure on the syringe barrel is released, which allows the skin to relax and slide up along the needle. The angle of attack is now slightly increased by lifting on the back of the syringe, and a forward motion of the syringe barrel causes the needle point to penetrate the vessel wall. The operator should be able to see the wall slide up the needle. The needle is aligned with the long axis of the vein so that the point is not pushed through the opposite wall but is instead threaded up the lumen of the vein. Gentle withdrawal on the plunger of the syringe will initiate the blood flow. The needle is withdrawn with a slight rotation movement, and a cotton ball is placed over the wound. Samples taken from other sites are drawn in the same fashion, but the bend in the needle is not usually required.

Caution: No one should attempt to take blood samples without first receiving instruction and supervision from an experienced practitioner.

Sample Handling

HEMATOLOGY. Immediately, place small drops of blood on films for white cell number counts. Two hematocrit tubes are filled for packed cell volume and total plasma solid determination. The remainder of the sample is divided depending on evaluations desired.

OTHER ANALYSES. Determination of lead concentration and other toxic substances requires a sample of whole blood, while serology, serum chemistry, and blood gasses are performed on plasma samples. For the latter, best results are obtained if the blood is immediately centrifuged and the plasma removed from the red blood cells. Centrifuges that can be operated in the field are available. Subsequent handling should be in accordance with the procedures indicated by the receiving laboratory.

Tolerance for Blood Taking

Healthy birds have a blood volume of about 10% of normal body weight. For instance, a healthy Peregrine Falcon of 800 g weight would have approximately 80 cc of blood. It is quite safe to remove 0.5% (4 cc) of this blood without risk of causing undue harm to even a wild bird to be released immediately. At this level there is no absolute need to place the bird in a safe environment to be observed and rehydrated if necessary over a period of 24 hours. It is not recommended to take larger volumes from wild birds and hold them overnight for fluid replacement.

Figure 7. Hooded Peregrine in a constraining device called an *aba* (T. Maechtle, in prep.), prepared for taking blood from the cutaneous ulnar vein of the wing.

Microbiology

Samples are collected from the pharynx, cloaca, and trachea as part of preliminary diagnosis. Samples from open wounds are taken as needed.

MATERIALS AND EQUIPMENT. Samples may be collected with a sterile cotton-tipped swab if they are going to be immediately inoculated on a plate. For cloacal swabs, moistening the swab with sterile saline will cause less pain and damage to tender cloacal tissues. If transport of the samples to a laboratory is a requirement, then a swab with transport medium (Culturette, Sci Products, AM Hospital Supply, Evanston, IL), is recommended. Tracheal cultures are taken with an alginate-tipped nasopharyngeal swab (Hardwood Products, Co., Guilford, ME). Thrust deep into the trachea as the bird holds its glottis open for inhalation. It is important the swab comes in contact with an area of the trachea 30-50% in from the glottis.

CULTURE MEDIA. The standard plates to be inoculated from the cloacal and pharyngeal swabs of each bird include a blood agar plate (BAP), a McConkey's type media, and a Sabouraud's dextrose plate for the tracheal swab specifically tailored to recovery of avian pathogens (NCACS, Rapt. Ctr, U. of Minn, 1920 Fitch Ave, St. Paul, MN 55108; blood analysis avail, 612/624-3018). Plates are streaked in conventional fashion and incubated at 37° C for 18 to 24 hours and then examined. It is beyond the intended scope of this manual to provide a detailed description of laboratory procedures for further recovery and identification of pathogenic microorganisms.

Parasite Sampling

EXTERNAL PARASITES. In general, external parasites such as lice, mites, and hippoboscid flies are collected from feathers and taken to a laboratory for analysis. Small screw cap vials filled two-thirds with 70% ethanol provide a satisfactory transport container and medium.

INTERNAL PARASITES. Samples may be taken from the pharynx, nares, trachea, esophagus, and cloaca:

A. The principal tracheal parasite encountered is *Syngamus.* In a live bird, it appears as small red worms. Affected birds typically exhibit respiratory difficulty and coughing. If worms can be seen through the opened glottis, they may be removed with a pair of fine tip tweezers and placed in alcohol.

B. A principal parasite of the pharynx and esophagus is a protozoan known as *Trichomonas,* the causative agent of "Frounce". A nematode known as *Capillaria* is also common. Trichomonads may be collected by scraping obvious lesions or plaques within the mouth with the back side of a knife or scalpel blade. The material is placed in a few drops of warmed saline on a glass slide and examined at 40x. The organism dies quickly if cooled and is difficult to find if it is not motile. In a less certain way, a moist swab can be inserted into the mouth and crop, then wrung out on a saline pool on a glass slide. The likelihood of recovery of organisms in the absence of obvious lesions is slim. *Capillaria* are most frequently diagnosed on the basis of their lemon-shaped ova in a fecal sample.

C. Cloacal samples are really fecal samples. Whole feces (the dark parts of cloacal excrement) are required to find the eggs of nematodes, trematodes, ascarids, tapeworms, and various coccidia. It is best to collect fresh (within a few hours) mutes (feces) from the floor or other objects within a hack box or eyrie in a plastic syringe case with the aid of cotton-tipped applicators and transport the sample for flotation, centrifugation, and microscopic examination. Samples should not be frozen as this may lyse the eggs of fragile species, rendering them unrecognizable. Direct smears on glass slides are also useful.

Tissue Biopsy

Biopsies are typically conducted to retrieve a small amount of adipose (fat) or occasionally pectoral or pelvic limb muscle tissue for pesticide analysis. Such a procedure is inherently more invasive than any other sampling procedure and carries with it a small risk of hemorrhage and similarly small, but very real, risk of infection. Equipment includes:

A. Providone iodine surgical scrub (xenodine sol.; Solvay Animal Health, Mendata Heights, MN 55120) 70% alcohol rinse and cotton swabs to clean skin.

B. Scalpel handle with #15 blade and small tissue handling forceps with smooth as opposed to serrated jaws for handling friable fat samples.

C. Glassware cleaned according to specifications by the laboratory to which the sample is being submitted.

PROCEDURE: Fat biopsies are regularly taken from the pad of adipose tissue found on the ventro-lateral aspect of the tail base. With the bird restrained on a thick towel, the feathers around the base of the tail are moistened with alcohol and moved aside. The skin should be cleaned by two applications of betadine surgical scrub applied with a cotton-tipped applicator and then rinsed lightly with 70% alcohol. The skin is then incised with the scalpel blade for a distance of 0.5 - 1.0 cm in a curved incision extending from the dorsal midline, laterally around the ventral and basal part of the tail, exposing the fat pad. The forceps and scalpel blade are then used to tease a 0.5 gm mass of fat from the pad. With a small incision, closure is not necessary but a dissolving suture material may be used if necessary. The wound should be treated with a small amount of iodine solution on an applicator. Hemorrhage, if it should occur, can be readily controlled by applying pressure with a cotton-tipped applicator for 1-2 minutes.

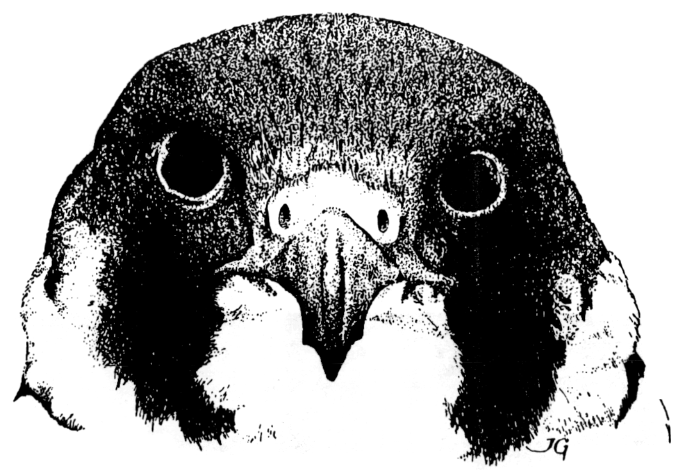
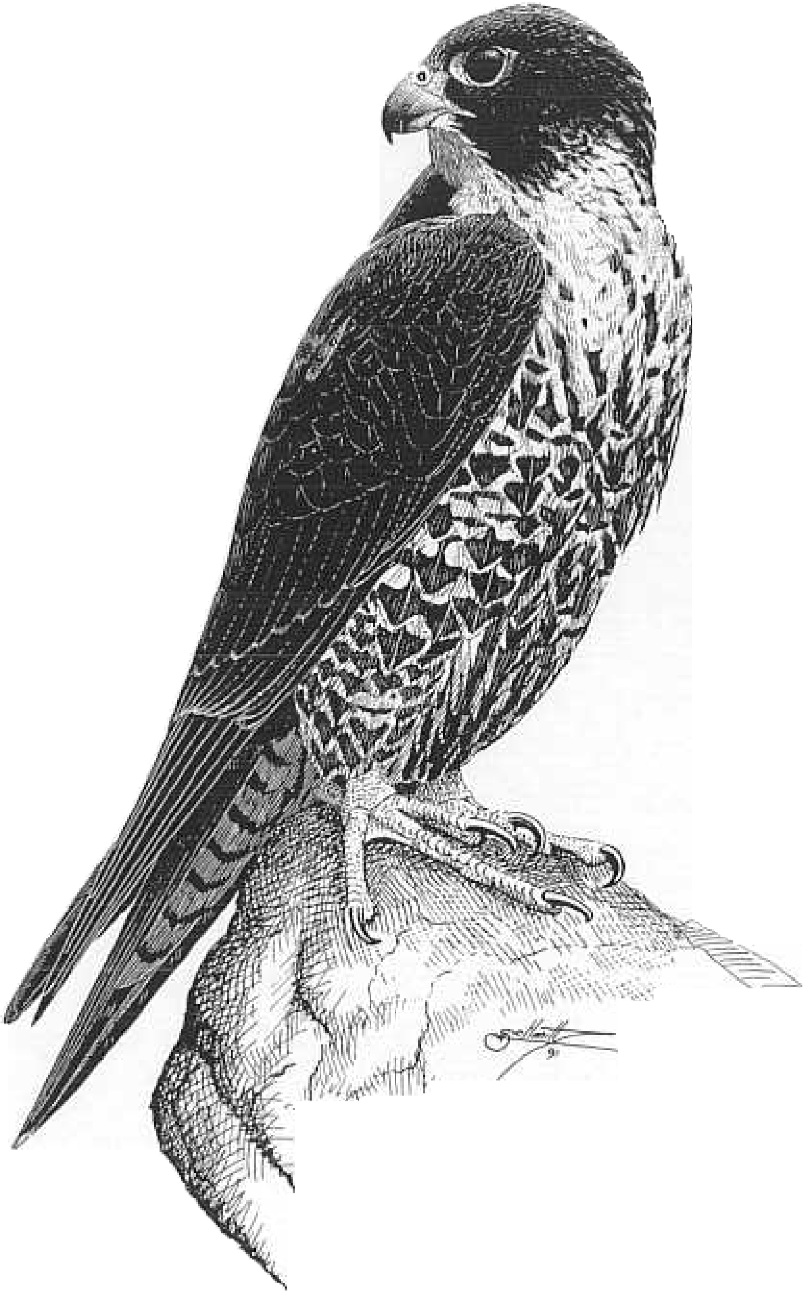


Table 1. Blood Sample Collection Procedures.

PURPOSE OF SAMPLE	TYPE OF SAMPLE AND COMMENTS ON HANDLING AND ANALYTICAL PROCEDURES	COLLECTION SITE	EQUIPMENT AND MATERIALS TO USE	VOLUME REQUIRED
General Health Determination	Packed Cell Volume/Total Plasma Protein	Brachial Vein Cutaneous Ulnar Vein Saphenous Vein	1. 1 cc tuberculin syringe without heparin 2. Hematocrit tubes	0.1 cc
Total and Differential White Cell Count	Whole blood smeared into thin films on microscope slides. Outcome is very sensitive to handling and preparation technique.	as above	1. 1 cc tuberculin syringe 2. Cleaned microscope slides	0.1 cc
Serum Chemistry	Plasma: (heparin, typ), separate plasma w/in 1 hour, refrigerate for short term storage, freeze if samples will not be run c/in 12 hours.	Brachial Vein Jugular Vein	1-3 cc syringe c/21-35 gauge needle	Equipment dependent 0.1-3.0 cc. typ.
Heavy Metal Analysis	Whole blood in appropriate anticoagulant — usually performed by atomic absorption spectrophotometry.	Any large peripheral vein	3 cc syringe c/21-25 gauge needle	1 - 3 cc
Organochlorine Pesticides	Plasma taken from whole blood in appropriate anticoagulant. Analysis by gas chromatography. Sensitive to equipment and skin contamination. Obtain specific protocol from cooperating laboratory.	Any large peripheral vein	3 — 12 cc syringe with 21-25 gauge needle	3-10 cc
Organophosphate Pesticides	1. Whole blood, plasma, occ. brain tissue. Analysis done by measuring cholinesterase activity by spectrophotometry. 2. Direct analysis of stomach contents	Brachial Cutaneous Ulnar	1 cc syringe	
Hormones:T4/T# Corticosterone, Reproductive Steroids	Plasma: 0.5 - 1.0 cc. Analysis by radioimmunoassay. Store blood in ice bath until centrifuged, freeze as soon as possible at -50C.	Brachial Cutaneous Ulnar	3 cc syringe with 25 gauge needle, collect in heparin	1-3 cc
DNA Analysis	Whole blood: 0.5 cc in specific lysing buffer solution from cooperating laboratory. Stores well at room temperature.	Brachial Cutaneous Ulnar	Tuberculin with 25 gauge needle containing 1 cc of lysing buffer	1 cc total volume
Antibody Analysis: e.g., Aspergillosis, Newcastle, Other Infectious Disease	Plasma: 0.2 - 0.5 cc Analysis by agar gel precipitin, ELISA or other immunologic base procedure	Brachial Cutaneous Ulnar	Tuberculin with 25 gauge needle, collect in heparin	0.5 - 1 cc

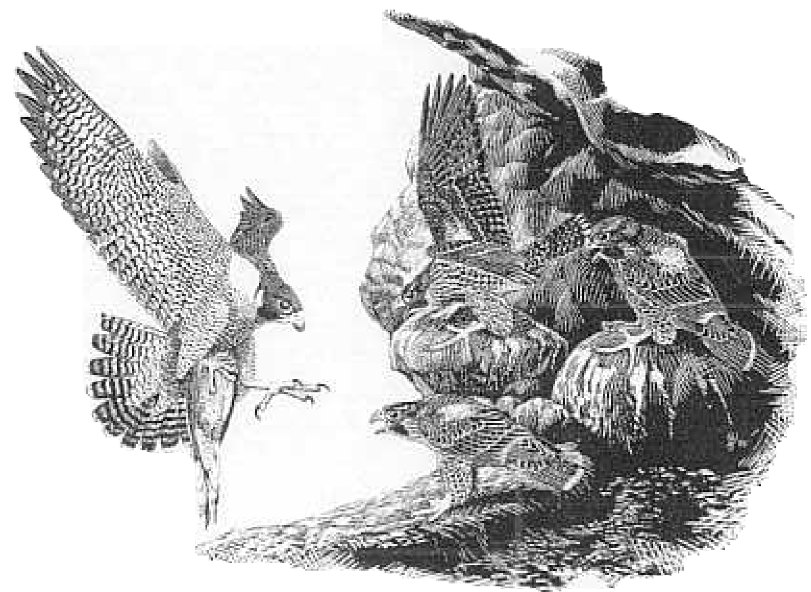


V. AGING YOUNG PEREGRINES

Nancy Clum, Peter Harrity, and Willard Heck

The following photographs demonstrate the pattern and timing of development for pre-fledged, captive-produced Peregrine Falcons as documented at The Peregrine Fund in Boise, Idaho. The landmarks described here generally appear within one day of the age indicated. We have given the earliest age in our descriptions. The only exception is the more variable emergence of the greater primary coverts, which we have seen appear as early as 13 days. We have described the emergence of the greater primary coverts at Day 16 because we feel it is more typical for them to erupt after the primaries, rather than before. From age 25 days on we have provided photographs of two different birds to illustrate the degree of variation in loss of down feathers prior to fledging.

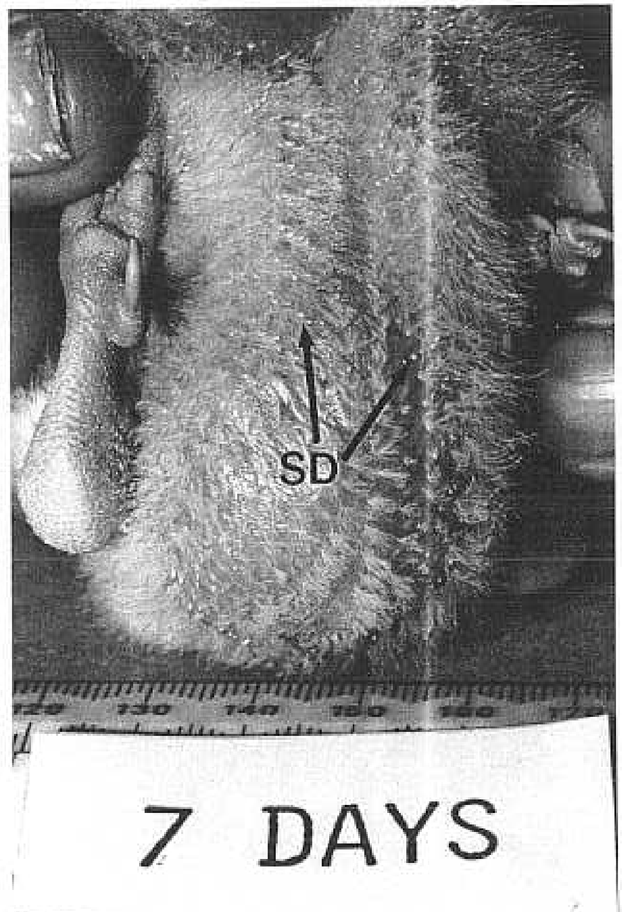
While we have found these patterns to be quite consistent within our population of birds, it must be emphasized that differences among individuals, between sexes, and between captive and wild birds may be greater than we have observed in our descriptive study. It has been suggested that female Peregrines, which fledge up to several days later than males, may also be slightly behind males in the appearance of developmental landmarks. It has also been suggested that these landmarks are reached significantly earlier in wild birds than in captives, in response to differences in nutritional or environmental conditions. These possibilities should be borne in mind when aging birds at eyries. Quantitative studies are needed to support or refute these claims, as well as to establish the level of individual variation in rates of development in both captive and wild birds.



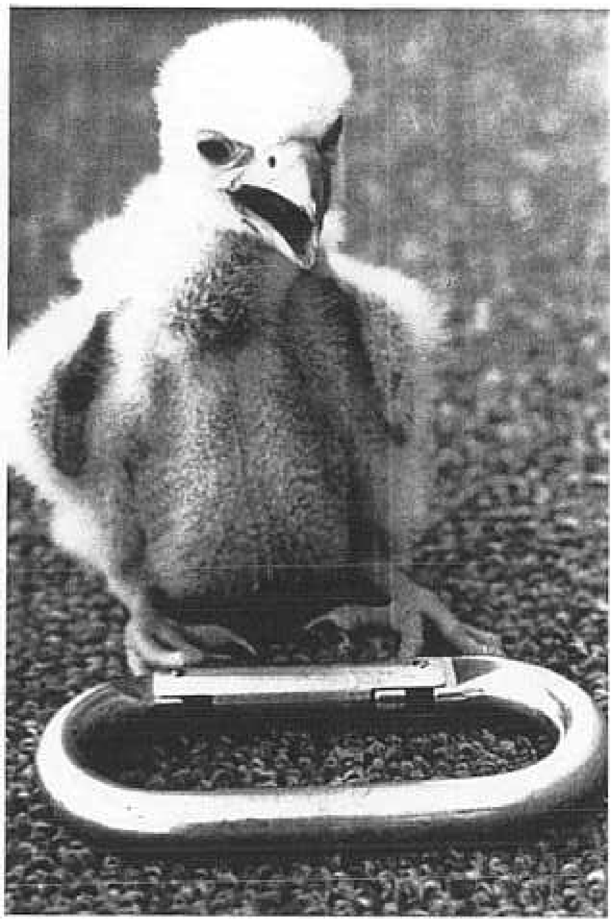
A first-day chick weighs between 35 and 40 grams and may still have some matted, unfluffed down. Its eyes are usually closed except when food-begging. Note that the open eye is slit-like. The chick's movements are very feeble at this age.

By five days the chick's weight has doubled, and it sits up with relative ease. Note the open eye is more round than slit-like. Through five days of age there is no evidence of second down (SD) emerging anywhere on the body.

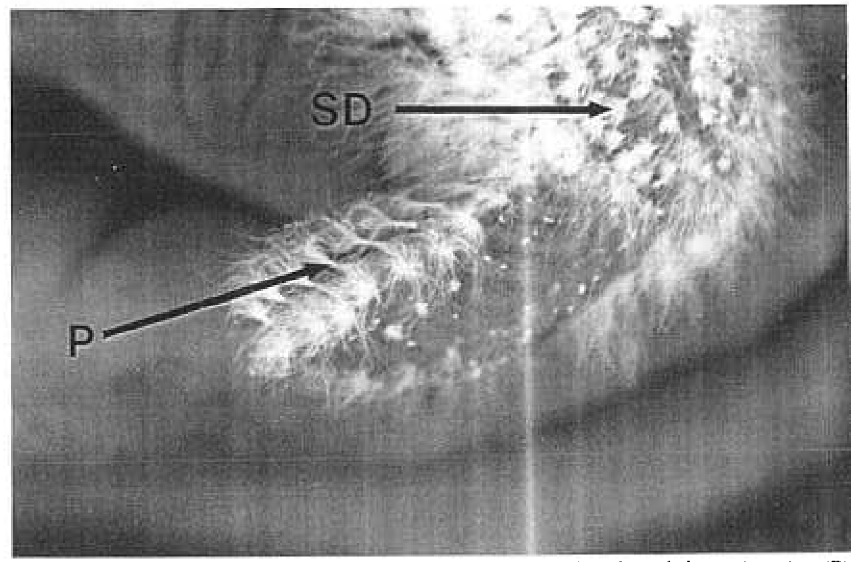
The first obvious landmark for aging occurs between six and eight days of age, when the second down emerges. The second down emerges at different ages in different feather tracts. It emerges first in the humeral and alar tracts, on the dorsal surface of the wing, at day six. The small, scattered white spots are the second down. No second down is visible on the abdomen at six days.



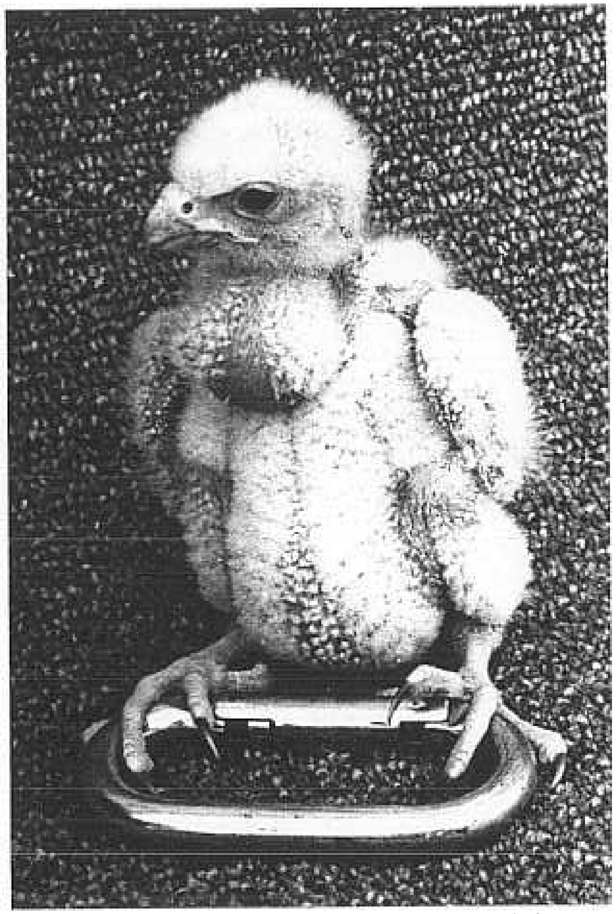
At seven days the second down begins to emerge in the ventral feather tracts on the belly, and in the femoral and crural tracts on the dorsal or upper surface of the legs.



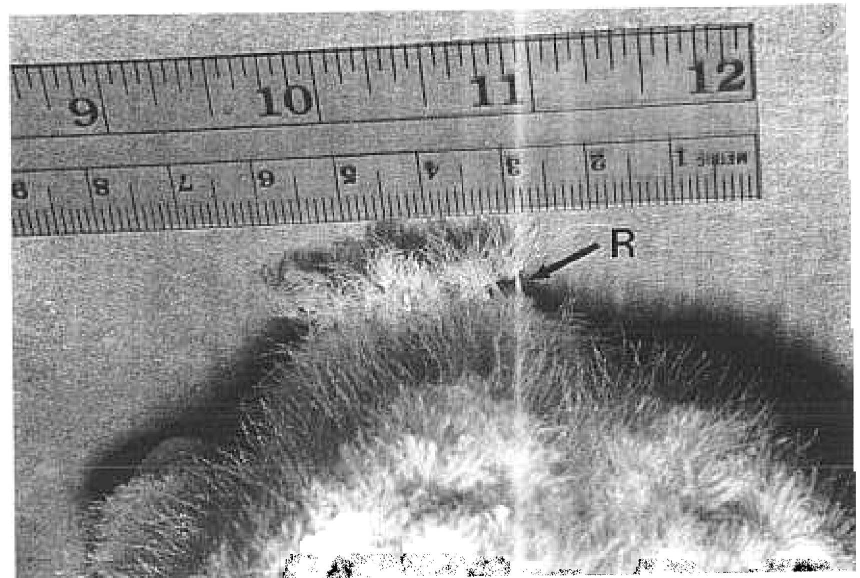
At eight days the second down begins to emerge in the spinal tract along the backbone (not shown). At this age the second down has uniformly emerged and is readily visible on the belly and legs.



The second down is well out on the wings, and the sheaths of the primaries (P) have just emerged at the margin of the wings.

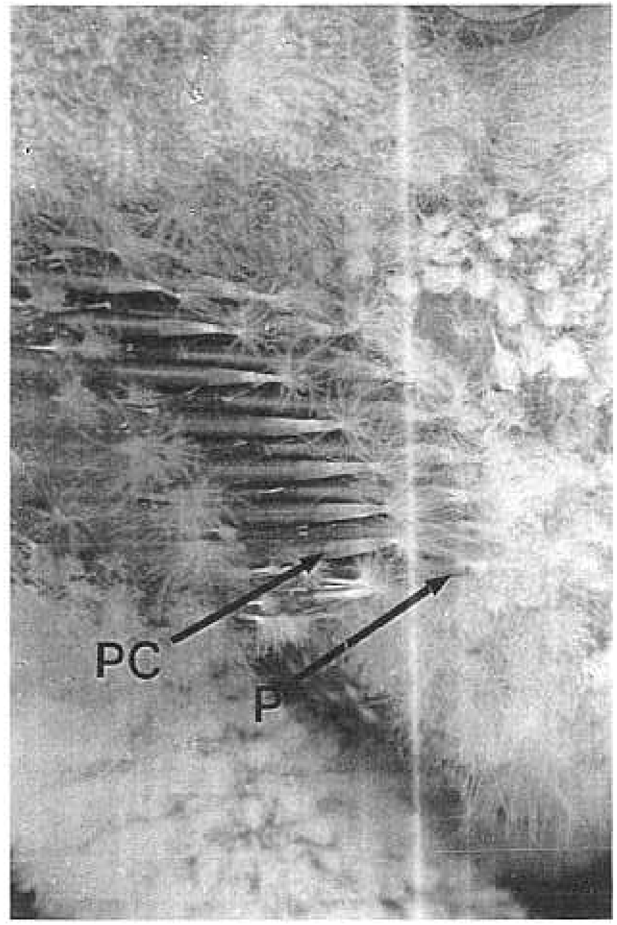


At 10 days the overall character of the second down is more uniform and complete compared to the eight day chick. At this age the unsplit sheaths of the primaries are several millimeters long, and the sheaths of the greater primary coverts have emerged above the primaries, usually by day nine.



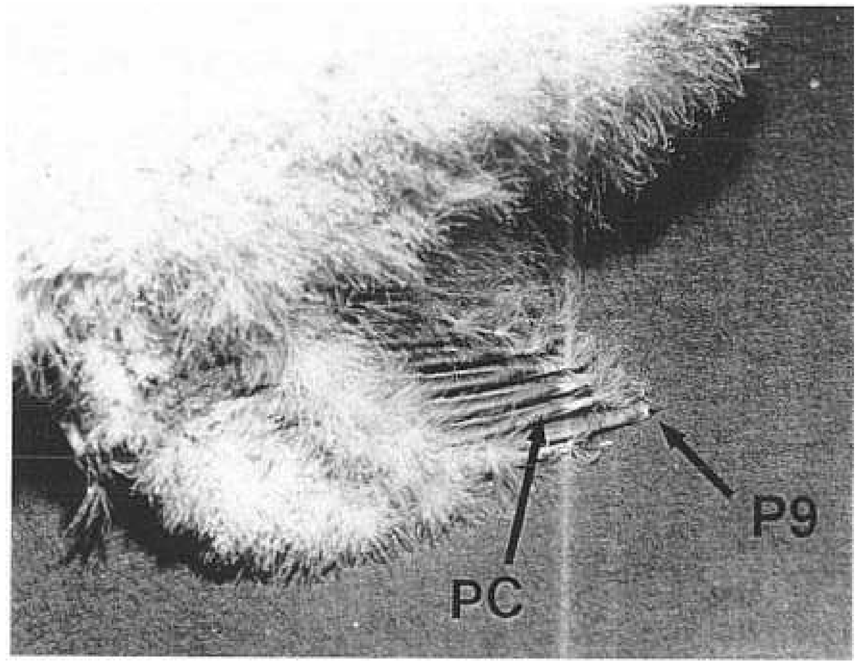
At this stage the unsplit sheaths of the tail feathers, (rectrices, R) emerge from the margin of the tail. Generally the outer rectrix is most readily visible through the down.

At 12 days the second down is becoming dense, but the individual down feathers are still distinguishable. The ear orifice has become distinct.

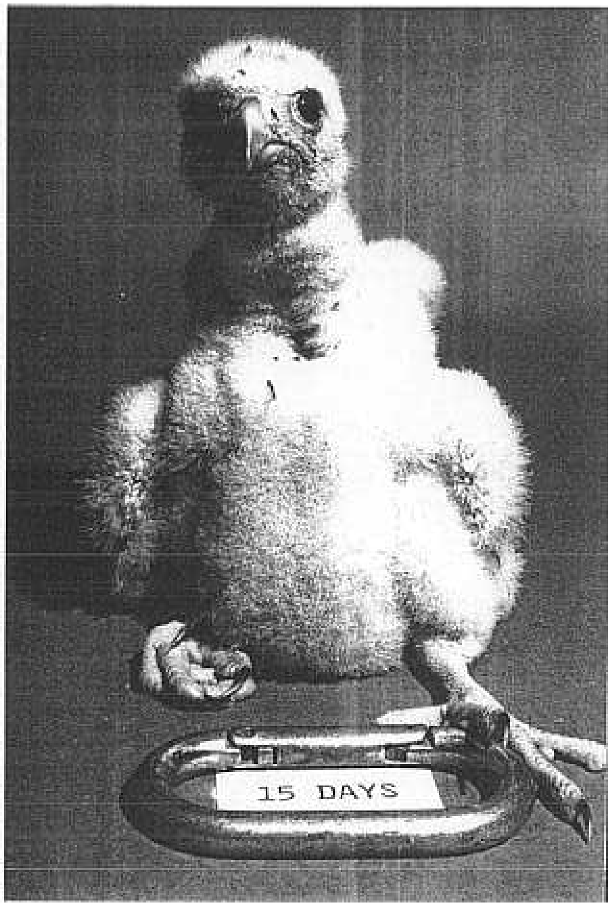


The primary sheaths and sheaths of the greater primary coverts (PC) continue to grow at the rate of two to three millimeters per day. The tail sheaths are more visible but have not yet split.

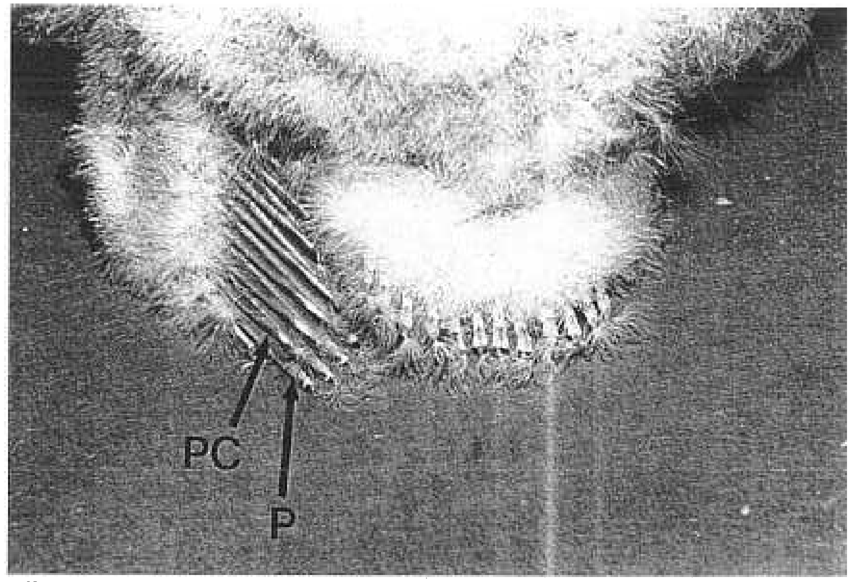
By 14 days, the second down is quite long, and the bases of individual down feathers are no longer visible. The tail is about two millimeters long, and the rectrices have started to emerge from their sheaths.



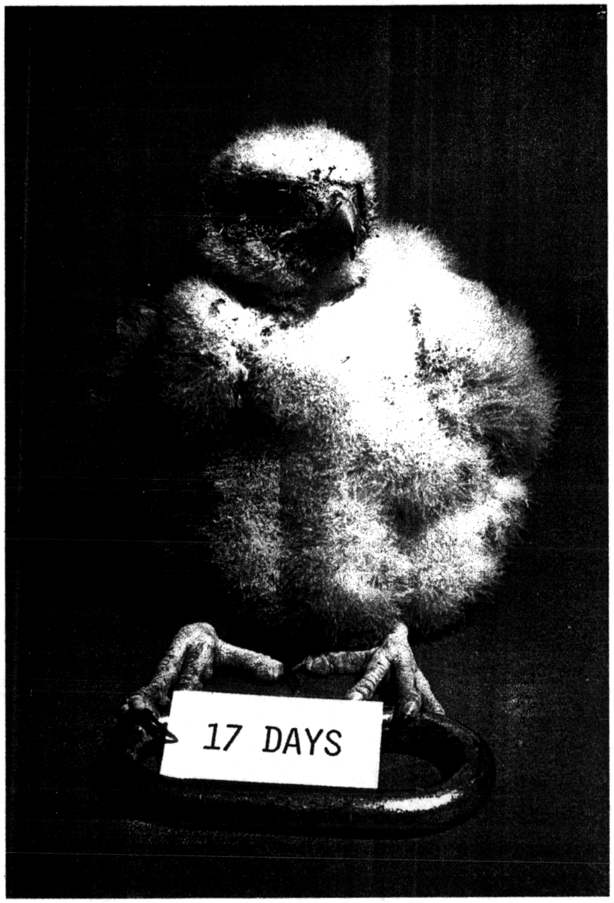
The ninth primary usually emerges from its sheath at this age. It is typically but not always the first to emerge.



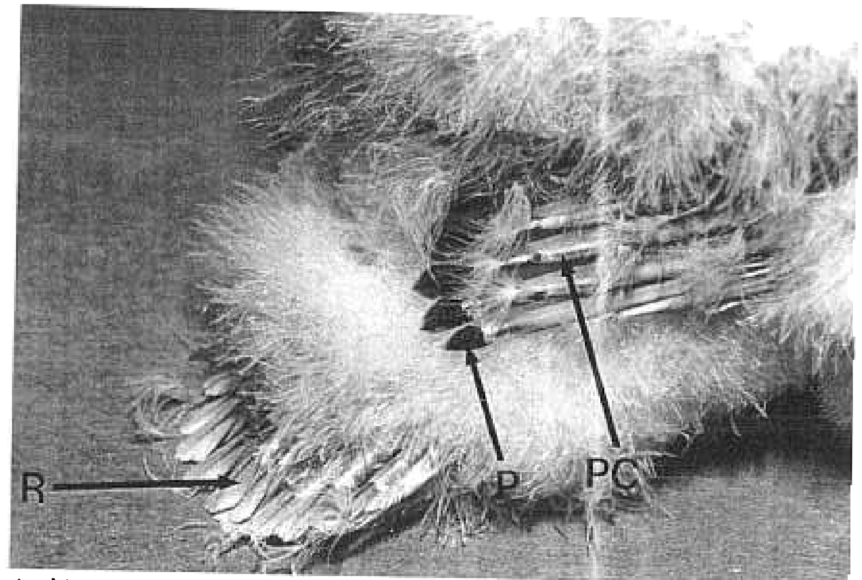
By 15 days the chick sits upright when disturbed or to preen and is quite alert.



All primaries have emerged from their sheaths, but the greater primary coverts and the alula feathers (not shown) still have not broken their sheaths.

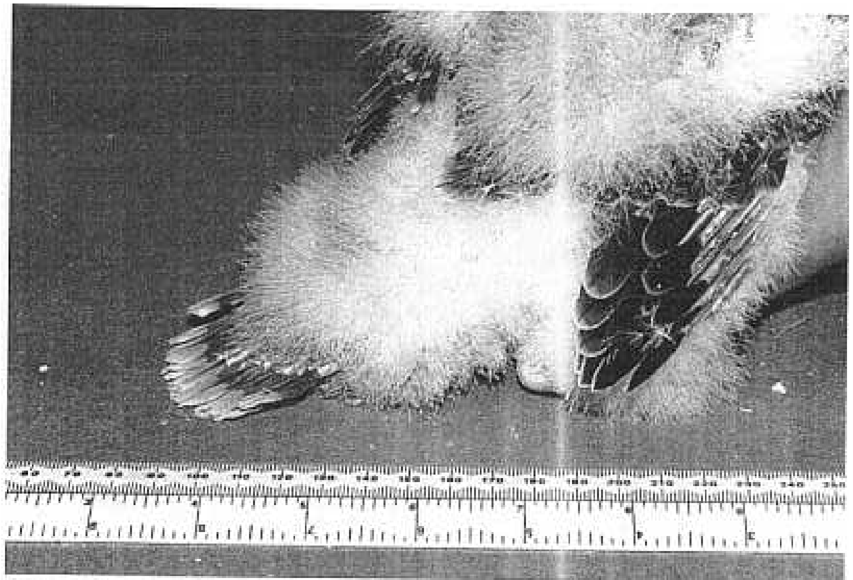


By 17 days growth of the contour feathers (still hidden by down) begins to push out the second down, causing it to look less uniform in length, giving the chick a fluffier, less matted appearance than at 15 days.

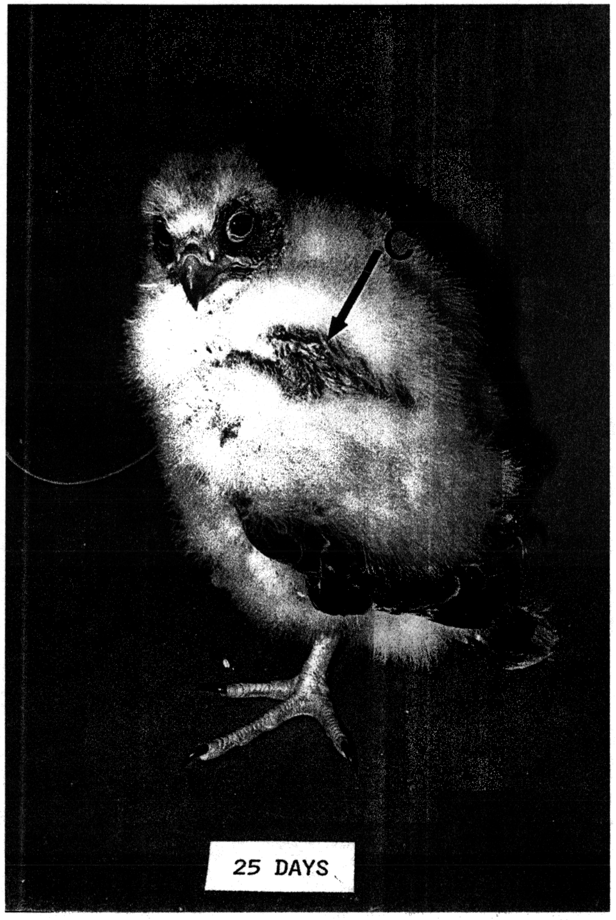


At this stage the alula feathers (not shown) emerge from their sheaths and the greater primary coverts have broken their sheaths (usually at 16 days), and the portion of the tail feathers that has emerged from the sheaths is still only the light-colored tip.

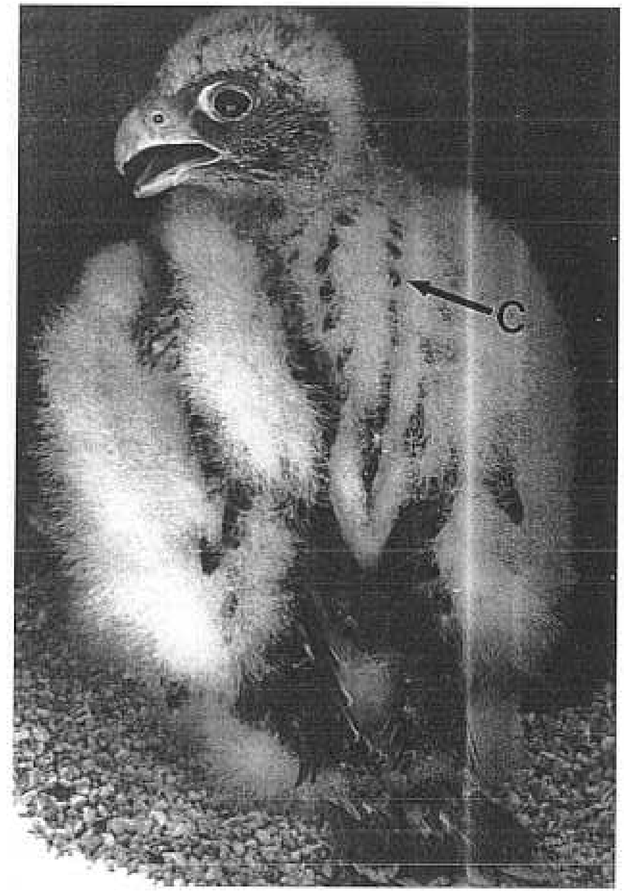
At 20 days the chick still has a heavy coat of down with contour feathers visible only at the margins of wings and tail, and faintly around the eyes and base of the lower mandible.



Up to about three weeks of age chicks can be accurately aged by measuring the emerged portion of the tail and assuming a growth rate of 2 mm/day after day 13.



By 25 days, the chick is capable of standing and walking but still spends most of its time resting on its tarsi. At this age, body contour feathers (C) are visible through the down. Emerging feathers in the humeral tract are readily seen.



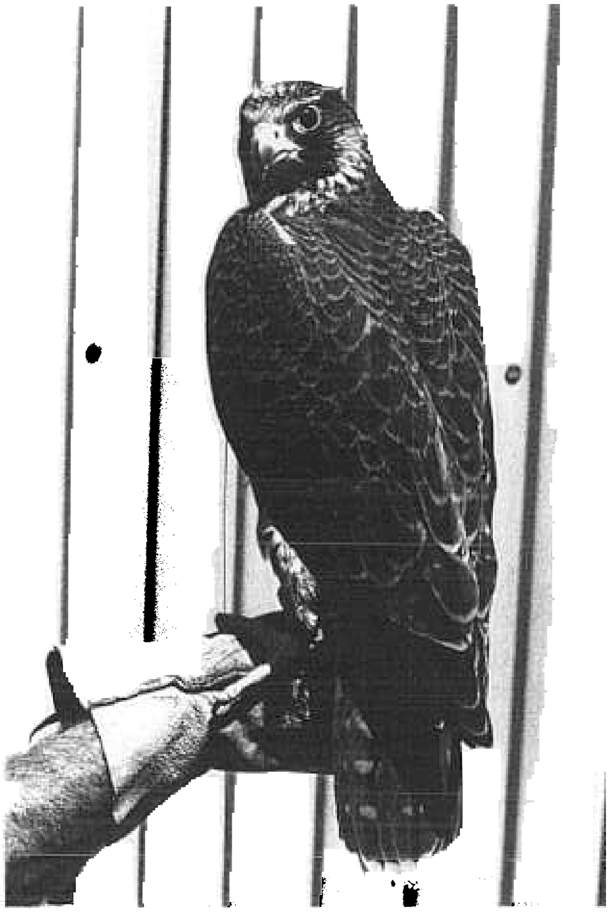
When elevated and relaxed, emerging feathers in the spinal tract are also visible.

By 30 days the chick appears to be about half downy and half feathered.


The face is well feathered, but the top of the head is still covered with down adhering to the tips of the contour feathers.

By 35 days the chick is largely feathered but retains large patches of down around its legs, wings, and top of head.

All primaries, secondaries, and tail feathers are still blood-rooted and growing.



At 40 days, the young Peregrine is almost fully feathered, although traces of down remain on top of the head and under the wings.

The outer three or four primaries and the outer two or three pairs of rectrices are not yet fully grown in, but the bird is capable of weak flight.

VI. MANAGEMENT GUIDELINES FOR SPECIFIC TYPES OF EYRIES

John H. Barclay

Figure 8. Nesting substrate and eggs at a California eyrie.
Courtesy of C. Himmelwright

Discussion

During their recovery in many regions of North America, Peregrines have resumed nesting in historical haunts that were vacant for many years. With increasing frequency, they have also established territories in new, human dominated settings. This has redefined the concept of Peregrine habitat. There are several subtle qualities of a Peregrine nesting site, or "serviceable breeding location" (SBL, Hunt 1988). The basic requirements for an SBL are physical relief which provides protection from predators, shelter from the elements, an acceptable substrate for egg laying and incubation, and an available prey base within usable distance from the nesting site. These conditions are met in a variety of natural settings including cliffs, cutbanks, and trees, and on man-made structures such as buildings, bridges, and even ships at anchor.

Conflicts between nesting Peregrines and human activities are bound to increase as the falcons reoccupy natural sites and use new sites in urban settings. Successful nesting, whether on a natural cliff or a city building, requires certain physical conditions, and freedom from disturbance. The raptor biologist should evaluate each type of nesting location and determine whether any of the fundamental conditions which contribute to successful nesting can be optimized. In this section, I discuss several aspects of nesting sites that can be managed to improve conditions for nesting Peregrines.

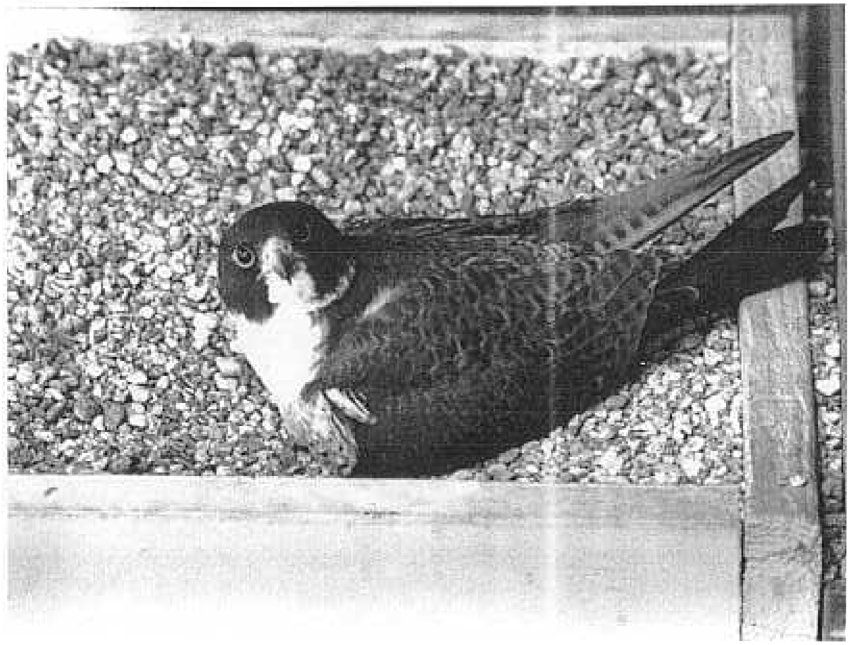


Figure 9. Artificial nesting substrate with incubating falcon in California

Cliffs

MINOR EYRIE IMPROVEMENTS/ENHANCEMENTS. The material on the floor of a nest ledge or pothole is important because it is the substrate in which falcons make their scrape and lay their eggs. This material provides the proper thermal and physical microenvironment for egg incubation and embryonic development. These conditions are met by a variety of materials including finely grained gravel, sand, soil, and windblown debris, or a combination of these. If the nest ledge is reasonably accessible, the substrate should be inspected during the non-breeding season to determine whether it provides acceptable conditions for the eggs and nestlings. Most important are the drainage characteristics and the texture of the scrape material. If the nest ledge appears poorly drained because of slope or texture, it can be modified to improve its drainage. Fine pea-sized, rounded gravel (0.5 cm diameter) can be added to improve drainage. Large or sharp stones should be removed so the nest cup does not contain any objects that might damage the eggs.

The physical features of the ledge and scrape dictate living conditions for the nestlings and often make the difference between their survival or loss. It is important that the ledge provide shelter for the nestlings from rain, wind, and sun, and to some degree protection from predators. The ledge should be relatively flat and unobstructed so the adults can enter and leave and the nestlings can move freely around the entire ledge. Large rocks and vegetation may need to be moved or adjusted to provide shelter from the elements, but still allow the birds to move easily around the ledge. A berm may need to be built along the edge of the ledge to contain additional gravel and keep it from spilling off the ledge. Likewise, a sloping ledge increases the risk that the nestlings will tumble off. In these cases the substrate should be graded to provide a level surface.

MAJOR EYRIE IMPROVEMENTS/ENHANCEMENTS. Falcon eyries have subtle physical characteristics that are not always evident to humans. For this reason, we caution against unconsidered modification of Peregrine nesting ledges. Major modifications should only be considered at eyries where there is a chronic history of nest failure, the reasons for the failures can be attributed to the physical characteristics of the nest ledge or scrape, and most importantly, where it is practical to improve them. Necessary permits and landowner permission should be obtained before undertaking any major Peregrine eyrie modifications.

Large-scale eyrie enhancement should be carefully considered and attempted only if appropriate conditions for successful nesting are inadequate or absent. Custom eyrie improvements can range from minor enhancements to large-scale improvements or the creation of nest ledges or potholes.

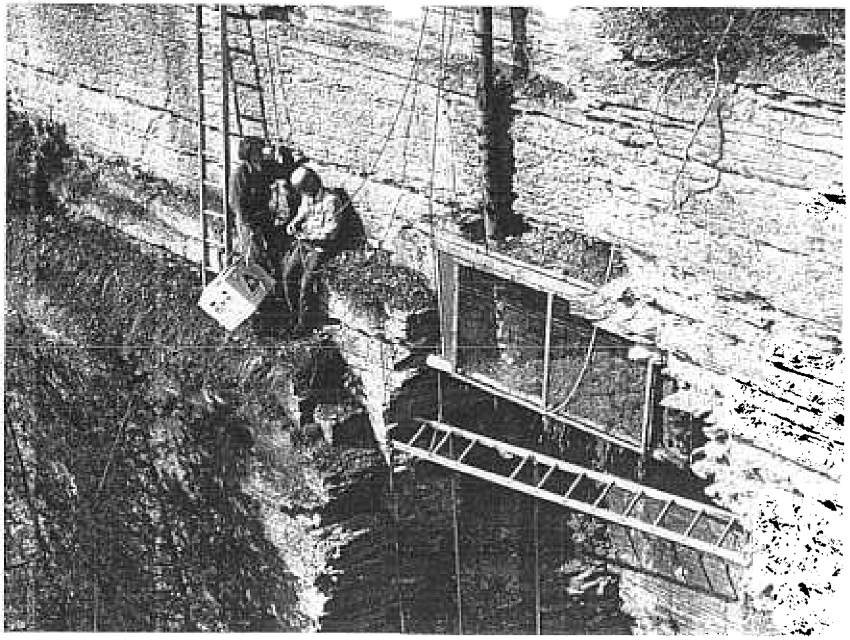


Figure 10. Artificial eyrie (hack site) built into side of cliff at Taughannock Falls New York, 1975.

If the ledge is poorly drained because of slope, drainage can be enhanced by chiseling grooves in the surface of the ledge to improve subsurface drainage. If chicks are exposed to rain or water seepage they may die from hypothermia. This is probably one of the most significant causes of nestling mortality. It is important, therefore, that the nest ledge provide shelter for the nestlings from rain and wind. In some cases an artificial roof can be erected over an exposed ledge, or a nest box can be anchored in place.

Ledges that are too small to allow nestlings to move about freely and stand up and exercise their wings can be enlarged by judicious excavation. As a guideline, a nesting ledge should provide enough space to allow the young to stand up and flap their wings on the edge of the ledge. If these conditions are not present, then ledge modifications to provide more horizontal and vertical space may be warranted. If this is impractical, an alternative would be to place one or two wooden perch poles extending out from the ledge to provide more space for the young to exercise without requiring rock excavation.

Artificial ledges or potholes can be created by excavating or blasting if the substrate permits. Excavating a nesting ledge is labor-intensive and dangerous, so great caution should be exercised. Only persons experienced in doing this type of work should attempt it. In Germany, volunteer army engineers have created nest sites by blasting. Expert knowledge is required to set the charges in the right positions to achieve the desired results.

Eyrie Access

Peregrine nesting cliffs should be evaluated for the potential for human disturbance to nesting falcons. Peregrines usually establish territories early in the spring before hiking, rock climbing, and other recreational activities begin. The falcons may nest in an area which is free from recreational use early in the spring, but which later receives a lot of human use. In some cases, hiking trails and climbing routes that intrude into a nesting territory can be temporarily closed or diverted until after the young falcons have left the ledge and it is no longer the focus of activity for the adults and young. Closures should be established in the spring when the birds begin courtship and extend into the summer until after the young leave the nest ledge.

Rock climbing increased greatly in popularity during the years in which Peregrines were relatively scarce or absent. Consequently, as Peregrine numbers increase, falcons are re-inhabiting cliffs that have in the interim become favorite climbing routes. Rock climbing is serious if it occurs in close proximity to the nest. Unlike most forms of disturbance caused by recreationalists such as hikers and picnickers, a climbing party may be on the rock face all day or even a number of days, and could cause nest failure if the Peregrines are disturbed by the activity. However, it must be borne in mind that in many cases the Peregrines have chosen to reoccupy a cliff that is already being climbed, and many pairs do not seem disturbed by climbing that does not directly approach the nest. For example, El Capitan in Yosemite Valley has hosted a pair of Peregrines since 1978. This rock face undergoes tremendous climbing pressure throughout the nesting season, except in an area of seasonal closure around the actual eyrie. The Peregrines are not at all disturbed by climbers on other portions of the face, where there can be five to ten or more parties at a time. Climbers report that they greatly enjoy watching the Peregrines, except that a stooping falcon can sound like a falling rock!

Climbers can be a great source of information to raptor biologists. It is well worth the effort to cooperate in turn, and to do whatever is possible to accommodate both Peregrines and climbers. Any closures because of nesting Peregrines or other raptors should be seasonal, and should be lifted once young have fledged from the nest. The size of the closure should depend on the reactions of the Peregrines to climbers, and may be influenced by the topography of the cliff. Observation of individual behavior may be particularly important at sites where the Peregrine nesting season begins before climbers arrive, because these Peregrines may or may not be tolerant of climbing if it is not occurring when they choose the spot.

Public relations on behalf of Peregrines can be enhanced by informing hiking and climbing organizations about the birds. The cooperation of their members can be extremely helpful in obtaining information on the whereabouts of nesting Peregrines and in enforcing temporary trail closures.

Nesting falcons are much more sensitive to people above their eyrie than to people below or across from it. For this reason, it is advisable to close trail sections above nesting ledges. It is especially important to close any trails and climbing routes that allow access to the ledges Peregrines are using for nesting.

Sensitivity

Falcons nesting in remote wilderness areas tend to be relatively intolerant of human encroachment in their territories. Conversely, falcons that choose to nest where they are exposed to regular human traffic are usually more tolerant of humans. The proximity at which nesting falcons accept human traffic without alarm is variable and should be carefully evaluated when planning trail closures. Our experience has shown that closure areas around eyries where falcons are accustomed to moderate levels of human activity do not need to be as large as those in remote locales where the birds rarely encounter people. Furthermore, individual falcons vary greatly in their tolerance of disturbance.

Logging, mining, road construction, and blasting are activities that are potentially disruptive and need to be controlled in the near vicinity (roughly one-half mile) of falcon eyries. Determining the minimum distance at which these activities can be allowed without disrupting the birds requires an evaluation of the falcons' behavior and tolerance. There are no hard and fast rules because several factors can influence the falcons' reaction to activity. The timing of the activity, especially in relation to the nesting season, habituation to a particular activity, and its location in relation to the eyrie all influence the birds' tolerance. Generally, activity below large cliffs is less disruptive at closer distances than activity above or behind a nesting cliff.

As a guideline, we suggest that activity within one-half to one mile of a nesting cliff be restricted during the period from courtship through the dispersal of young, depending on the activity. We want to emphasize, however, that it is important that a biologist familiar with the behavior of Peregrines at their eyries evaluate the potential impact of human activity in the vicinity of occupied eyries.

Artificial Towers

GENERAL CONSIDERATIONS. Nest towers offer opportunities to establish breeding pairs in areas where nesting structures are absent or sparsely distributed. Towers are usually used for hacking for two or three years until adult Peregrines become established. Towers can also be built to attract breeding Peregrines in areas where hacking has occurred and there is an established population of adults. It is a good idea to establish Peregrine towers on refuges, sanctuaries, or land in protected ownership where human activity is limited. Towers require periodic maintenance as described later.

It is important to remember that Peregrines nesting on towers are easily disturbed by humans. Because there is no concealment in the open areas where towers are located, the falcons are sensitive to activity at greater distances than they would be on cliffs. Locating towers on islands or in areas that are difficult to access on foot can minimize the potential for inadvertent human disturbance. Generally, vehicle or boat traffic alone is less disruptive than when people get out and approach the eyrie.

AESTHETIC CONSIDERATIONS. Some people find artificial towers to be aesthetically unattractive because they are conspicuous foreign structures that impose upon the natural features of landscapes where they are constructed. These objections can be minimized by locating towers in remote areas where they are less noticeable. Public education can be useful in explaining the purpose of the towers and their role in endangered species management.

SPECIAL PROBLEMS. When selecting prospective tower sites, consideration should be given to potential impacts the Peregrines might have on sensitive bird species. Unwanted predation on locally rare species such as Least Terns, Piping Plovers, and Snowy Plovers *(Charadrius alexandrinus)*, and other colonial waterbirds should be avoided when choosing locations for Peregrine towers.

MIGRATING PEREGRINES. The establishment of tower-resident Peregrines in a few areas has caused agonistic encounters between the resident falcons and migrant Peregrines. This situation has interfered with migrant falcon banding operations in the vicinity of the towers. These interactions are more disruptive of the trapping operations than they are threatening to the survival of the migrant birds. Competitive interactions between tower-resident falcons and migrating Peregrines can be avoided by locating towers away from known Peregrine migration and stopover places. It should be recognized that aggressive encounters are natural events which occur on the breeding grounds as well as between resident and migrant Peregrines.

TOWER DESIGN AND CONSTRUCTION. The booklet "Hacking; a method for releasing Peregrine Falcons and other predatory birds" (Sherrod et al. 1982) contains recommendations for constructing hacking towers. The manual describes the standard four-pole tower with a ten-foot square platform supporting a four-foot deep by five-foot wide by three-foot high hack box. It should be noted that this size platform and box are not necessary for the successful nesting of reintroduced pairs. A nest box approximately two feet by three feet in floor area with a two-foot high roof is sufficient. This standard four-pole design has proven to be durable and practical to construct. Some alternate tower designs (e.g., three-pole tripod and single-pole) have been built in special circumstances. These structures have withstood severe storms and exposure for several years with no structural problems.

Figure 13 shows a single-pole tower built in Ocean Gate, New Jersey on AT&T's transcontinental communication station. The platform was constructed on a cut off pole that was originally about 125 feet tall. This pole extended some 25 feet below the surface, so with supporting guy wires it provided enough strength and stability to support a platform and hack box. The platform and hack box were built the same as on a standard four-pole tower except that a hatch door was cut into the platform above the pole to provide access. This type of tower construction is suitable only where there is a supporting pole that is large enough and deep enough to provide sufficient structural strength for the platform and hack box, which weigh several hundred pounds.

A "teepee" or "tripod" tower constructed on Great Fox Island, Virginia offered some advantages in construction, and it provided some structural advantages over the four-pole design. Recently two-pole towers have also been constructed.

Figure 11. Standard four-pole nesting tower, Sedge Island, New Jersey Note metal predator guards.

We have often been asked about the minimum height for Peregrine towers. There really is no accepted minimum height; Peregrines have been successfully hacked from towers as short as ten feet tall and nested on towers just over 20 feet tall. We feel that the chances of having an artificial tower satisfy a Peregrine's requirements for a nest site are better if the tower is at least 20 feet tall. What is important is that the tower be tall enough to provide the falcons protection from ground predators while being easy to build without special equipment.

Ospreys and some other birds construct nests on tower platforms or on top of hack/nest boxes with flat tops. This can be avoided by building the platform with a minimum amount of extra area around the box and by building the box with a steeply sloping or peaked roof. Barn Owls *(Tyto alba)* sometimes nest inside the hack/nest boxes, especially if there is a hide panel inside which provides concealment. For this reason, we remove or cover over the corner hide panel inside boxes used for hacking. Towers constructed to attract nesting Peregrines should have a nest box without a hide panel installed.

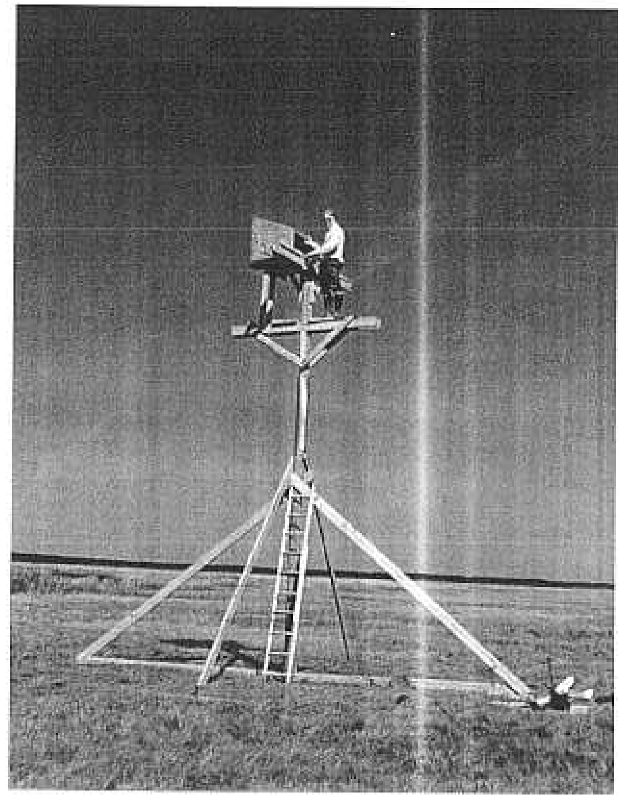


Figure 12. Single-pole nesting platform in use in Virginia Salt Marshes. *Courtesy of M. Byrd*

MAINTENANCE. Exposure to rain and strong winds may progressively weaken the tower structure and cause it to fail. Towers and their accessories should be inspected and repaired annually. The vertical and horizontal cross bracing members between the poles should be examined and tightened as needed by installing more bolts or additional wooden braces. Any loose platform planks or hack box panels should be firmed up with additional nails or screws. Guy wire bracing between the tower and sand anchors is important for tower stability in loose marsh soils. They should be inspected annually and tightened so they provide stability.

The sheet metal sleeves or cone-shaped predator guards on the poles are one of the most important parts of the tower, and one of the easiest to fail. These guards should be smooth and free of holes or nails in their mid-sections so that climbing animals cannot gain a purchase and climb the tower. Heavy grease applied to the predator guards can work as an additional deterrent while also retarding corrosion. Guards that have become rusted or bent should be replaced.

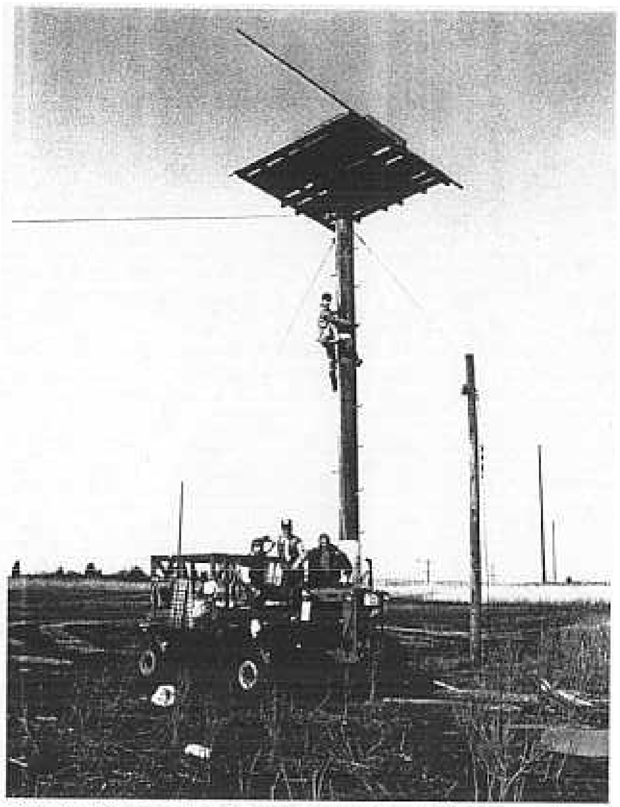


Figure 13. Single-pole tower at the AT&T Long Lines Station, Ocean Gate, New Jersey

The gravel in the nest box should be cleaned of prey remains and excrement. There should be at least four inches of smooth, pea-sized gravel in the box. Gravel with smooth pebbles is obtained from river deposits; crushed rock must be avoided.

OTHER ACCESSORIES. Each tower should have at least two lightning rods installed above all other parts of the tower. Lightening rods should be grounded using appropriately installed heavy gauge grounding wires and connectors which should be examined annually for security and firm connections. Perch poles extending off the platform should be inspected for secure attachment and fixed as needed. Because many areas where towers are located do not offer alternate perches in the vicinity, we suggest installing two to four, eight foot tall "T" perches 50 to 100 yards from the tower. The falcons regularly use these structures as alternate perches and as cache sites.

Urban Sites

NEST SITE PLACEMENT. Experience has shown that Peregrines select a variety of nest sites in urban environments. These include hack boxes used for releases, specially constructed nesting trays, buildings and bridges containing ledges with wind-blown material, and structural cavities. One cannot always predict the building or structure that Peregrines will select for nesting. Some of the sites falcons choose contain features that prove hazardous for successful fledging of young. When trying to manage urban nesting Peregrines it is best to offer several secure options for the adults, thereby minimizing the chances that birds will select a site that is hazardous for the young. Managers of urban-nesting Peregrines should consult Saul Frank's book *City Peregrines* (1994) for many important and instructive details about falcons living and dying in New York City.

Urban Peregrines often establish a territory during the winter on the building or structure that they will later nest on. It is best to identify their favorite structure before they select a nesting site and then provide nesting boxes for them to discover. By watching the bird(s) it is usually possible to identify their favorite haunts, e.g., a certain ledge, corner, logo sign, or other architectural feature. Gravel-filled nest boxes should be placed near favorite perches. Nest trays should be at least six inches deep and two feet wide by four feet long. They must be heavy enough to prevent movement from high winds or vibration on bridges, and they should be securely anchored.

When deciding where to place nest boxes, one should consider the needs of the adults and young during all stages of nesting. Sites for nest boxes should have unobstructed access for birds in flight. The falcons usually select nest sites that afford a clear view of the airspace in front of the ledge. There should also be shelter from prevailing winds, rain, and direct sunlight.

Generally, an appropriate combination of nest site qualities can best be met on building ledges. When nest boxes are placed on a ledge, a site more closely resembles the structure of a ledge on a cliff face. Rooftop sites are generally less suitable for nesting because they are more exposed and require some form of structure to be constructed to provide protection from the elements.

POTENTIAL HAZARDS. Experience from hacking falcons in urban environments has shown that there are many potential hazards to young, inexperienced falcons. The area around a prospective urban nest site should be thoroughly evaluated for potential risks. Because young falcons are inexperienced at landing, structures such as chimneys, open ducts, narrow vertical cavities, and air conditioning cooling fans are particularly hazardous. Any open cavities with narrow edges where young, inexperienced falcons could fall in if they overshoot their landing are especially hazardous. It is important that open structures and cavities around a prospective nest site be covered with netting or screen or otherwise modified to prevent entrapment. The area around the eyrie should be examined for other hazardous structures such as microwave antennas and uninsulated electrical fixtures. These structures should be modified or the site moved away from them.

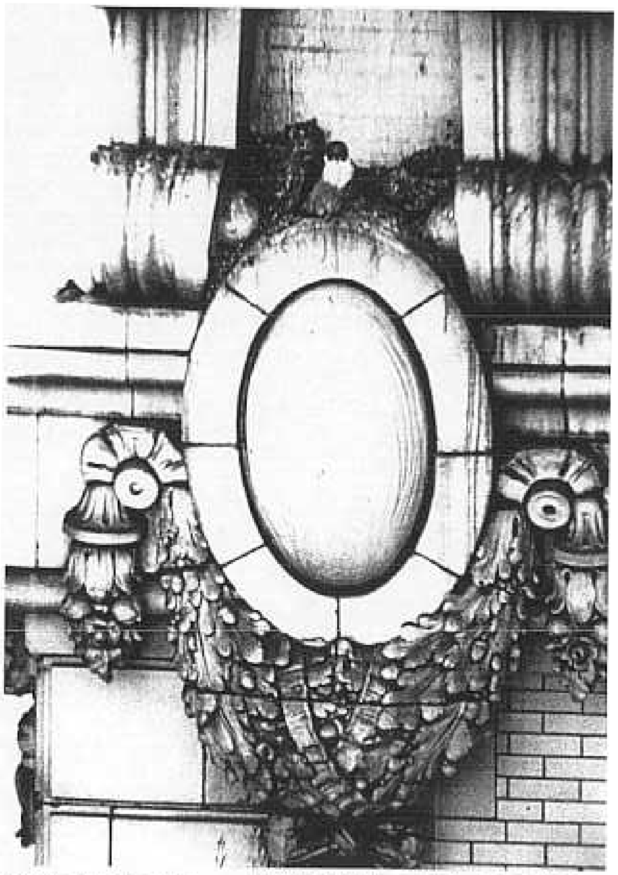


Figure 14. Nest site on old Hotel Utah building in Salt Lake City.

Figure 15. Nest box on abandoned water tank tower, Tuckerton Fish Factory, New Jersey.

Buildings with large facades of reflective glass pose a potential risk of collisions for adult and young Peregrines. There is no way of modifying these conditions so the only option is to select, if possible, buildings that are removed from those with glass facades.

BUILDING MANAGEMENT RELATIONS. Peregrines pose a new set of considerations for building owners, and building management personnel are understandably concerned about their liabilities associated with biologists working on the building and how the falcons may disrupt building maintenance activities. It is important to develop a good working relationship with building supervisors. Many building operators require a Hold Harmless Agreement or other form of self-insurance for biologists engaging in activities on their buildings. It is often possible to reach a compromise with management personnel so that the falcons can nest unmolested while minimizing interference with building operations.

Figure 16. Peregrine nest box at the U.S. Fidelity and Guaranty Building, Baltimore, MD. Adult male feeding young on 33rd story window ledge.

Most buildings have restricted access to rooftops and ledges, which is beneficial in reducing human disturbance of nesting Peregrines. Gaining the cooperation of building management to reduce maintenance activities can help minimize disturbance. The behavior of the birds during nesting, especially their defensive response, should be explained so that building personnel will not be attacked. It is safer for maintenance people and the falcons to suspend window washing until after nesting is completed.

In the interest of good relations, prey remains and excrement should be periodically cleaned around the site. It is best to do this right after the young have dispersed since the building is littered with prey remains and whitewash at this time.

There are numerous opportunities for positive public relations when Peregrines nest on a city building. Public relations can further the cause of conserving rare species and enhance the public's perception of the building owners. Press coverage of building-nesting Peregrines should be supervised and limited to controlled situations in order to avoid inadvertent disturbance. At some building sites closed circuit video systems have been installed to allow live monitoring of the falcons, with monitor displays in the building lobbies. These programs have contributed to increased appreciation for Peregrine conservation. Live coverage of Peregrine nests has been broadcast on television, and recently, on the Internet.

SPECIAL PROBLEMS WITH URBAN SITES. City-dwelling pigeon fanciers often establish lofts on building roof tops. Since city Peregrines eventually find these lofts, it is a good idea to contact local keepers and discuss the problem, and the legal protection of the falcons. The attitudes of pigeon fanciers towards Peregrines vary, and their sympathy to Peregrine conservation usually depends upon the incidence of Peregrine predation on their flocks.

Inquire about any pigeon control programs in the vicinity of city-dwelling falcons. Programs that poison pigeons with substances that could kill Peregrines by secondary toxicity should be stopped. It is advisable and more effective to enlist the help of local wildlife law enforcement agents to control pigeon poisoning that may affect Peregrines.

Fledgling Peregrines sometimes end up on the ground or street. Although this occurs at non-urban sites, it is particularly dangerous at urban sites because of traffic and the reluctance of the adults to approach their young on busy city streets. Often, well-meaning people may pick up such birds and turn them over to rehabilitation centers. If found promptly, these youngsters can simply be returned to the top of the building. It is usually not necessary to return them to the actual nest ledge unless they left prematurely and are incapable of sustained flight. Biologists monitoring urban Peregrines should be particularly aware during fledging time. It is helpful to speak to several people who work in or near the nest building who can call biologists if young end up on the street. Nearby rehabilitation and animal control centers should also be alerted and given telephone numbers to reach biologists (including on weekends) if a young Peregrine comes to their facility. Too often young Peregrines are picked up by well-meaning members of the public and given to rehabilitation center operators who are unaware of the bird's origin. Sometimes, by the time someone familiar with the situation learns about such "rescued" young Peregrines, it is too late to return them to their building.

Anyone holding such a bird should be advised to keep it in a large, ventilated cardboard box in a cool, dark area away from disturbance. This prevents the youngster from injuring itself or its vulnerable, growing feathers. It is not necessary or advisable to feed such a bird unless it must be held for more than a day.

Bridges

Peregrines began nesting on bridges in New York City in 1983 (Frank 1994), and since then Peregrines have nested on a dozen bridges in the eastern United States as well as on others in the Mid-West and West (Cade and Bird 1990, Cade et al. 1996). The falcons usually perch under the roadway in the supporting substructure of large bridges. Complex bridge structures contain numerous potential nest sites with horizontal surfaces which provide a substrate for egg laying. Most of the sites Peregrines have used for nesting have been open ledges in the substructure framework or in structural cavities with accumulated wind-blown debris or pigeon feces. Occasionally falcons have used cavities in the superstructure above the road bed.

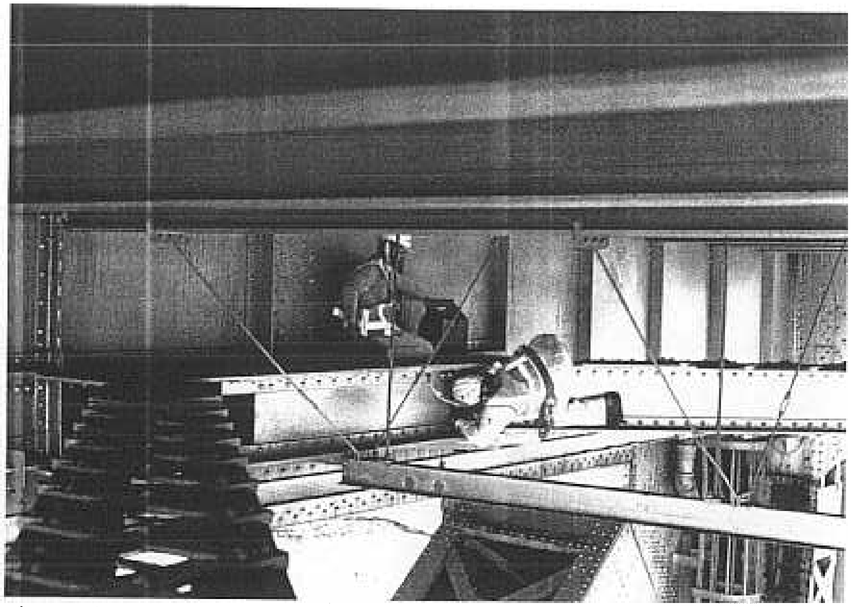


Figure 17. Nest site on Oakland Bay Bridge, where fledgling survival is low

Since the structural complexity of large bridges provides numerous potential nest sites for Peregrines, it is often difficult to determine exactly where the falcons have made their scrape. One has to watch the bridge carefully from a nearby vantage point that affords a clear view. If the birds' favorite haunts can be determined early in the season then it is worth providing them with a nest box containing gravel. Unfortunately, the birds usually select their nest site before it is possible to identify where it is and provide them an alternate. It is still a good idea to provide one or several nest boxes since they might be used in subsequent years.

Nesting trays, or boxes, should be constructed to fit in specific spaces available on the bridge. As a guide, a nest tray should be six inches deep and at least two feet wide by four feet long. Trays should be located where there is some protection from rain and prevailing winds. Depending upon the local site conditions, some shelter can be provided by attaching plywood panels to two sides of the nest tray. All must be securely attached to the bridge structure with bolts or cables. Bridges vibrate continually, and combined with strong winds, these forces can move a heavy tray and possibly cause it to fall off the structure. The bridge authorities often have their own requirements for securing nest boxes to the bridge structure.

Many bridge sites provide marginal conditions for rearing of young. Some bridge-nesting falcons have chosen ledges and cavities that do not offer enough space for the fledglings to exercise. In some cases, the young have fallen into the water because they were unable to move about and exercise before leaving the cavity, and they exited before they were capable of sustained flight. If the birds are

nesting in a setting that does not provide room for the young to move about and their survival is questionable, then some modification may be warranted. In some settings, installing a wooden, carpet-covered ramp from the nest ledge to other larger ledges can prevent the problem of premature fledging.

Bridges are painted or repaired routinely. This situation can be analogous to seasonal rock climbing that begins on nesting cliffs after the falcons are committed to their nest site. If the falcons' nesting attempt is likely to fail because of scheduled maintenance activity, try to negotiate a compromise schedule with the maintenance superintendent that allows the falcons time to finish nesting.

Strong winds, especially downdrafts, contribute to fledgling mortality at bridge sites. Strong winds often prevent fledgling Peregrines from safely landing during their initial flights, so that they miss their intended landing and fall to the water or land on the roadway. Depending on the bridge, it may be helpful to locate nest trays close to the mainland so the fledglings have a shorter distance to a safe landing. The best precaution is to station a biologist near the bridge to monitor the safety of the young during their first few days on the wing. Some of the hazards associated with bridges cannot be avoided. At sites where there is a history of mortality one should evaluate other management options such as removing the eggs or young and fostering them to other pairs nesting in safer settings.

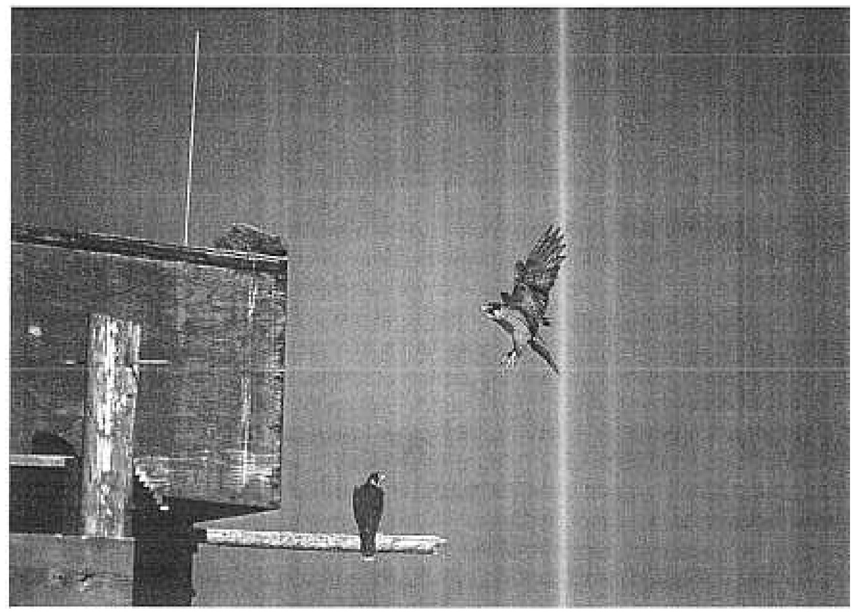


Figure 18. Adult female returning to hack tower and fledged youngster.
Courtesy of Rick Kline

VII. MANIPULATIONS IN THE FIELD TO FURTHER RESTORATION

Tom J. Cade and Janet Linthicum

Discussion

Harvesting eggs or young from wild pairs of Peregrines can be a much cheaper and more effective way to obtain birds for reintroduction or augmentation than captive propagation, especially if a source population exists near the area of work. The advantages of this procedure have been well demonstrated by the reintroduction programs for Peregrines in Colorado (Burnham et al. 1988) and California (Walton and Thelander 1988), for Bald Eagles *(Haliaeetus leucocephalus)* in New York (Nye 1988) and the south central states (S. K. Sherrod in lit.), and particularly for the Mauritius Kestrel *(Falco punctatus)* (Cade and Jones 1993). Especially when eggs are taken early enough in the cycle to allow for the laying of a second clutch, little impact is exerted on the local productivity of the donor population, and, indeed, the overall production of young by the donor pairs can be doubled. In cases where pairs have a history of nest failure (e.g., bridges), the removal of eggs or young to more secure sites seems fully justified, especially if it is not possible to increase breeding success by improving the characteristics of the eyrie as detailed in Chapter VI.

A healthy donor population that is at the carrying capacity for number of breeding pairs can yield up to 50 percent of its average annual production of nestlings for reintroduction over several years with no impact on replacement of lost breeders, owing to the existence of a large number of non-breeding adults (see Hunt 1988 and Newton 1988 for estimates of non-breeding "floaters" in wild populations, Conway et al. 1995 for lack of impact on breeding numbers of deliberate "harvest" of young birds in Prairie Falcon *(Falco mexicanus)* populations, and Nielsen and Petursson, 1995 for sustained harvest of 4848 Icelandic Gyrfalcons over a period of 62 years, 1731-1793). Such harvest does, of course, reduce the floater to breeder ratio, which should not be allowed to drop so low that adult recruitment into the breeding population becomes affected.

Transport of eggs and young is a very serious undertaking and requires determined consideration and planning to avoid accidents. Any unconsidered action can result in fatality of Peregrines and is unacceptable. All actions should be in consultation with experienced raptor breeding personnel, and "fail-safe" procedures should be used.

Timing is critical in fostering and cross-fostering efforts. Captive breeding provides young Peregrines throughout the breeding season through double-clutching. This means that young of the correct age may be selected for fostering or cross-fostering into a given wild nest. Availability may be more restricted when using wild breeders as donors, making the process more complex.

In the case of direct fostering efforts, Peregrines at different latitudes and altitudes lay eggs at different times. This means that fostering young between latitudes and altitudes may be difficult, because the fostered young should be of the same age as those already in the nest. This should be kept in mind when considering moving young Peregrines from one nest to another.

Figure 19. Climber descending to nest with young in ventilated box.

Both interspecific and intraspecific differences in breeding cycle are important in cross-fostering efforts. The Peregrine young should be the same age or younger than the chicks they are to replace. This may cause timing difficulties. For example, Prairie Falcons lay eggs later than Peregrines at similar altitude and latitude. In order to cross-foster to Prairies from wild Peregrine nests, it would be necessary to use a late-laying donor population, for example one from a higher latitude or altitude than the recipient (Prairie) population, so that the Peregrine and Prairie young hatch at roughly the same time of year. Another possibility is to foster Peregrine young to incubating Prairies. This requires that the Prairie eggs be collected, hatched in captivity, and then fostered to conspecifics, thus vastly complicating the procedure. These timing questions should be considered before undertaking a fostering or cross-fostering program.

Removal of Eggs

Eggs may be taken from nests in sequence as they are laid, leaving one egg or a dummy egg in the nest to hold the female's interest in the scrape and to stimulate further ovulation, or they can be removed as an entire clutch. In captive situations or for easily accessible wild nests there may be some advantages to using the first method, the chief one being that a large number of eggs can be induced over a relatively short period. The disadvantages are that egg quality may be greatly reduced after more than the usual clutch number has been laid, the eggs must be incubated artificially from day one, a procedure which results in a high failure rate (see Weaver and Cade 1991), and wild females may desert the eyrie with such frequent disturbance. A further practical difficulty is that many wild falcon nests require an arduous and time-consuming climb into them, and it is therefore more cost-effective to wait and collect an entire clutch (see Weaver and Cade 1991 for pros and cons of using these two methods with captive birds).

The best method, therefore, for harvesting wild falcon eggs is to wait and remove the entire clutch after 7 to 10 days of incubation. This amount of natural incubation is sufficient to insure a high rate of hatch in laboratory incubators (Burnham 1983, Weaver and Cade 1991). On the other hand, if a female is left incubating her first clutch for too long, she is unlikely to recycle and lay a second set after the first has been removed. We do not know precisely what this interval is for the Peregrine, but most females re-lay after a period of 10 to 14 days of initial incubation. In captivity the interval between loss of the first clutch and laying of the first egg of the second clutch is nearly always 14 days, but in the wild it can apparently be more variable — up to 25 days (Ratcliffe 1993), perhaps depending on how long the bird was incubating her first clutch before it was taken. Artificial incubation of Peregrine eggs and raising of young is a complex and time consuming process and should only be undertaken with proper consideration and preparation. Unless there are captive adult Peregrines to raise the young to near fledging, it is probably best to use this technique only for fostering programs. See Weaver and Cade (1991) for a detailed description of Peregrine husbandry techniques.

Obviously, intelligent harvesting of wild eggs depends on knowing when eggs were laid and when incubation began. It is not necessary to climb into the eyrie in order to determine these events. Careful, distant observation of the behavior of the pair will reveal the timing (Chapter II). Remember that falcons usually start incubation before the last egg is laid — usually with the second or third egg depending on weather. Consequently, when the female is first observed to go into the eyrie and remain for several hours, or to be replaced by the male who also remains for a long time, there may still be one or two eggs to be laid. As eggs are typically laid at 48-hour intervals, at least that amount of time ought to be added to the period calculated for a week of full incubation.

Collection and transport of wild eggs for incubation and hatching require considerable care, especially after eggs have been incubated for as long as 7 to 10 days and development is well under way. At this stage the egg contains an embryo and is developing delicate internal structures including blood vessels and other tissues. The main problems are to prevent overheating, severe and prolonged cooling, and vibrations or jarring movements that might tear delicate blood vessels or membranes inside the egg. Contrary to common belief, prolonged cooling is not

as dangerous to a developing egg as overheating. An embryo may quickly die if its temperature rises more than a few degrees above the optimum level, but it can withstand repeated episodes of cooling with no obvious effects other than an increase in total time to hatch. Developmental defects or death may occur if the cooling is too severe or too prolonged, but there is a great deal more latitude with cooling than with overheating.

An experienced climber who has received prior instruction in handling eggs should be sent down to the eyrie. A climbing helmet should always be worn, not only because of potential rock fall, but also owing to occasional strikes by defending adults. Care should be taken to prevent loose rocks, or even the climbing rope, from accidentally falling on the eggs as the climber descends to enter the eyrie. Falcons normally leave incubation posture slowly and carefully to avoid damaging the eggs. A startled falcon may bolt from the eggs, potentially damaging them. The climber should avoid throwing the rope close to the eyrie where the incubating bird can see it, thus potentially startling the incubating falcon. Instead, the rope can be thrown off to the side or eased down the cliff. On some descents it is advisable to stack the free end of the rope loosely in a bag clipped to the climber's harness, easing it out during the rappel. It is also wise to "warn" an incubating falcon of your presence by calling out during the descent. This allows the bird to leave the nest in a normal manner before beginning defensive behavior, and it also allows the climber to see exactly where the nest is, as cliffs can look quite different from the top. Upon entering, the climber should be secured so that both hands are free. The eggs should be handled gently, and shaking or spinning should be avoided. They should be placed in a compact, compartmented box with the small end of the egg pointed downwards or on their side, and secured so that they do not move. This can be done by using a sturdy box compartmented with foam rubber and using cotton balls to hold the eggs more securely. The eggs may have thin shells, so care should be taken to avoid any undue pressure on any part of the egg. The egg container should be placed inside a backpack for the ascent. Once the eggs are secure the climber can then place at least two dummy eggs, or fostered young, into the eyrie. If the pair is to be double-clutched, nothing is left.

Occasionally, an egg may have become dented or cracked during incubation. Unless the egg contents have leaked, the egg might still be alive. Such eggs should be placed in the carrier in such a way that they do not leak. In extreme cases, dents and cracks can be repaired with Elmer's glue and a Q-tip in the field. However, such eggs are unlikely to be alive, and repair is better done while using a candler, so it is best to hold off if possible. No egg should ever be assumed to be dead until it can be candled by an experienced individual. Some eggs with seemingly fatal dents or crushed areas have hatched in the laboratory. If pipped eggs (eggs with a small extruding bump or hole at the widest circumference of the egg, preparing to hatch) are encountered, the effort should be abandoned, lest a chick attempt to hatch while in a container or portable incubator.

Once on top, the eggs should be transferred to a portable field "incubator." Each egg should be nested in its own soft foam rubber pocket to protect against vibrations and contact with other eggs in the container. If the trip is to be more than a few hours long, the eggs should be housed in a battery or cigarette lighter powered incubator in which the temperature can be maintained just below

37.5° C. Several designs of such incubators are available. The incubator should allow air circulation throughout the egg chamber and to the eggs. Air circulation within the incubator is important to temperature regulation. The whole setup with dummy eggs inside should be tested for appropriate heat throughout the egg chamber before use. Temperature in the incubator should be stabilized before the eggs are obtained.

If the trip is a shorter one, then it may be sufficient to house the eggs in a thermally insulated compartment that has been preheated to 37-38° C and which is thermally stabilized with hot water bottles, etc. Again, remember not to overheat the eggs. Slow cooling in the insulated compartment will not harm the eggs over a period of hours. If necessary, the compartment can be re-heated during transit. Unless the eggs are going to be in the portable incubator for more than 12 hours, they do not require turning. Beyond this, it might be wise to turn them if they are on their side. Eggs should never be placed or handled pointed-end up. Avoid any concussion.

The external environment of the incubator should be kept stable as it has a dramatic effect on the temperature inside. Great care should be taken to avoid direct sunlight hitting the incubator, as that will cause overheating inside. A temperature probe which can be read externally should be mounted inside the incubator. One such as the Norelco Digital Thermometer Model HT986 works very well and can be inserted into various parts of the incubator through small 3 mm holes. Ideally, a temperature-sensitive alarm and a back-up thermostat should be part of the portable incubator design.

If the eggs have to be transported in a vehicle over rough roads, special care should be taken to prevent excessive vibration and jarring. The incubator may need to be placed on a pillow and hand-held in a person's lap or otherwise suspended to reduce the impact of the vehicle's movements on the eggs. The driver should take particular care to drive slowly and avoid jarring bumps. If possible, a helicopter or fixed-wing airplane should be used to get eggs out of really remote and rugged country. Once on a smooth road the incubator should be strapped down with a seat belt in case of sudden stops.

Figure 20. One version of a portable incubator.

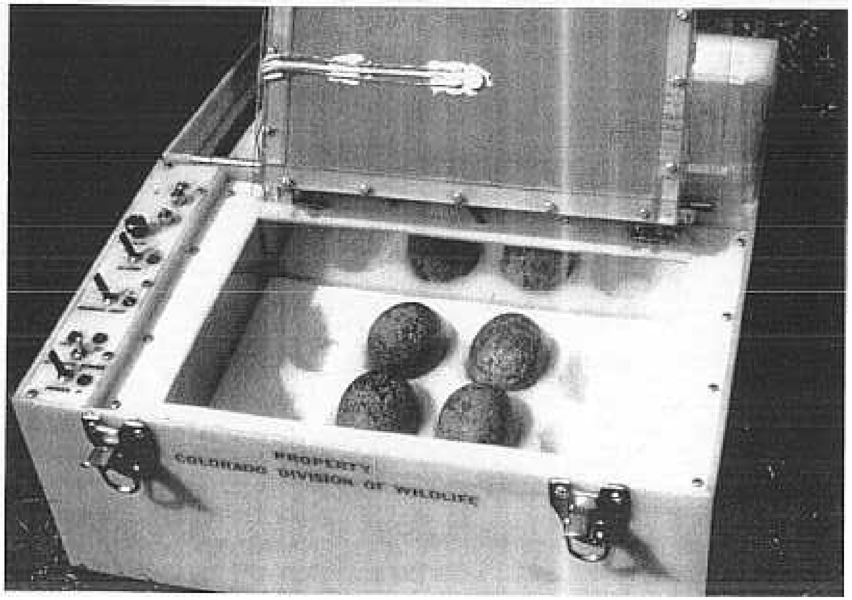


Figure 21. A slightly different incubator design

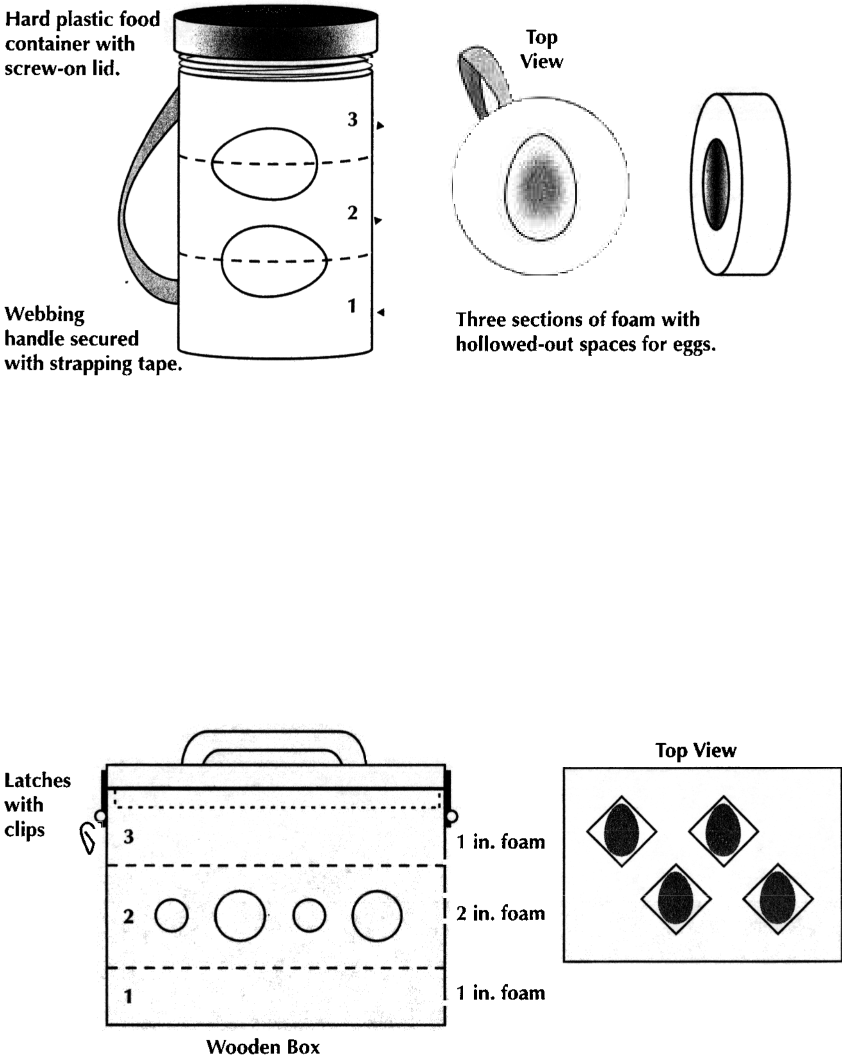


Figure 22. Two types of egg carriers

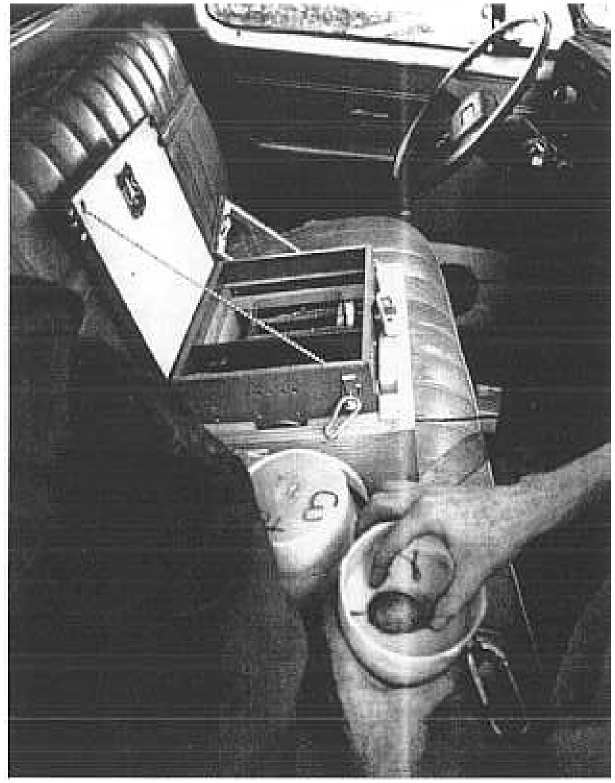


Figure 23. Eggs being transferred from field egg carrier to incubator secured for travel. Note external thermometer.

Translocation of Young

Young Peregrines can be taken from wild eyries for hacking or fostering into areas where new pairs need to be established or to supplement local productivity elsewhere. As indicated above, up to half the young could be taken from a healthy population existing at the carrying capacity of its environment without impacting recruitment into the breeding segment of the population. In practice, a lesser number will usually be taken, and except where there is a history of repeated failure it is probably always a good practice to leave at least one young in each nest to make sure the adults continue their attachment to the eyrie. In the case of eyries that consistently fail during fledging (e.g., many bridge sites), it is reasonable to take all the young for translocation.

The disadvantage of taking young for translocation instead of eggs is that it does reduce the local productivity of the donor population or donor pair, and this reduction could be a problem for populations that have not yet reached the carrying capacity of their breeding ranges. On the other hand, it eliminates the time and cost involved in artificial incubation of eggs and the captive rearing of the young falcons; it is, therefore, the cheapest and easiest way to obtain birds for translocation. Many tens of thousands of dollars could have been saved in Peregrine reintroduction programs if young for release could have been obtained from wild eyries instead of from captive breeding establishments. The former technique was successfully used for the reintroduction of Bald Eagles into New York State (Nye 1988) and other areas.

If young are to be translocated for fostering or cross-fostering then usually they should be removed from the donor eyries when they are still downy — up to but not exceeding about 21 days of age. One advantage of using birds that are from 18 to 21 days old is that they can be accurately sexed and banded prior to placement into the foster site, thus preventing an additional trip to band young at a later date. Older nestlings are likely to react with fear or aggression toward strange "siblings" or parents and thus not be accepted at the foster site. On the other hand, if the chicks are too young they are more likely to be injured accidentally or deliberately during the period of adjustment to the new family situation. The optimal age for acceptance by the young of the adults and siblings is 13-15 days. If young are fostered at this age they should be banded with female bands only, as incorrect placement of a male band on a female would produce injury or death. Although it may appear easy to sex young at this age, mistakes can be made owing to individual variation and unknown difference in age. It is never worth taking a chance. Chicks fewer than ten days old are not able to thermoregulate and should not be removed from nests because of the danger of chilling or over-heating during the climb to the donor or foster nest. Clearly, nests considered for fostering purposes, both donor and recipient, require careful observation throughout the nest season to assess age of young accurately.

Young of this age should be handled by lifting them with one hand from below, and securing them with a hand on their back. Legs and wings should be left free. Wings should not be allowed to impact carrier surfaces, to prevent damage to the alula. Young should be transported in a dark, spacious, and sturdy (wood) container with air holes. There should be enough space for the young to approach or avoid each other, depending on temperature requirements. During climbs, they can be kept in a ventilated wooden box with back-pack straps attached and worn like a snug day-pack. During transport, temperatures comfortable to humans are fine for young Peregrines. They should <u>never</u> be kept in a small container with no ventilation, covered with towels, placed in the sun, or otherwise allowed to overheat. Young Peregrines, especially when they have food in their crops, generate considerable heat of their own, and they quickly overheat if not given ample ventilation. Signs of low-level heat stress include lying down with legs and/or wings stretched out, and heavy breathing. Panting birds are extremely overheated. In both cases steps should be taken immediately. A spray bottle should be carried when transporting young to spray their down <u>lightly</u> with water if necessary to cool them. Again, while young should be in a relatively warm and draft-free container, they should never be confined in such a way that the heat they generate could build up in the carrier. If the chicks are young enough to need a heat source such as a hot water bottle with warm water, it should be placed on one side of the carrier so the young can approach or avoid it as necessary. Even one-day-old peregrines are capable of this behavior.

The best laid plans of the most qualified and well-intentioned biologists almost always run into snags. Therefore, when transporting young it is always advisable to be prepared for the unexpected. A common hot water bottle and a thermos of warm water should be carried in case of an unforeseen need for heat. Although young being removed and fostered on the same day probably do not need to be fed, it is always wise to have food on hand in case of unforeseen circumstances. Ideally, frozen coturnix quail meat ground without skin or viscera and flattened in Ziplock freezer bags can be sandwiched between blue-ice blocks and kept frozen in a cooler until thawed in portions needed. If this is not available, fresh Foster Farms chicken can be used. Unlike many raptors, young Peregrines are fairly susceptible to bacterial infection. Food should always be kept cold if not frozen. In case of doubt, it is probably better not to feed young than to use food that has been warm for any length of time. Food can be lightly moistened with Pedialite, an infant diarrhea replacement liquid readily available in drugstores. This helps replace fluids lost because of stress.

Young should never be fed until their crops have been empty at least one hour if not more. Wild young over 14 days old are usually leery of handlers, but may be induced to eat if pieces of food are placed in their mouths when they hiss. If this does not work, they are probably not hungry enough to need feeding. Young should not be fed more than enough to produce a soft bulge in the crop. Handlers should be aware that digesting food produces heat in young, and their temperature requirement may vary depending on food status. If Prairie Falcon young are being handled, they may be infested with lice (look in the axillary area for feces and lice). They may benefit from pyrethrine spray.

If brood supplementation is the plan, then the ages of the fostered young must be within three to four days of the young at the eyrie, and this match requires accurate, advance information about age of the young in the eyrie. The same applies to cross-fostering when a brood of young Peregrines is substituted for the foster parents' own chicks, although there is more leeway in this case for difference in age of the two groups. The Peregrines must be either of the same age or younger than the hosts' chicks. In any case, they must be downy.

If the wild pair has been held in the incubation phase on dummy eggs, downy Peregrine chicks may be directly substituted for the eggs. Although variable, most pairs of Peregrines do not incubate long beyond the time their real eggs should hatch. If there is any doubt about how tightly the adults are incubating, the safest plan is first to test the parental behavior of the pair with young of a common species before putting the young Peregrines under their care. Chicks should always be replaced with young of similar or younger age, never older. When young are placed into an eyrie where the adults have been incubating it should be kept in mind that the female may not be in as good hunting condition as the male, and the immediate food requirements of the young are high. Three to four quail or similar food items can be placed on the ledge away from the young to help the adults get started. The birds should be observed long enough to be sure that the adults are feeding the young properly. This can usually be determined within a few hours.

If the translocated young are to be used for hacking, then they can be left in the nest until they are four to five weeks old and taken just a few days before placement in the hack box. See Sherrod et al. (1981) for detailed recommendations on procedures for hacking falcons.

FOSTERING. The placement of captive-reared or translocated young into a foster nest has proved to be an effective way to supplement the productivity of wild pairs (Cade, et al. 1988). It is probably a more cost-effective way to establish young falcons in the wild than hacking, but it depends on the presence of a wild breeding population and does not help to establish Peregrines in vacant range, except to the extent that it may provide an increased number of "dispersers" that settle to breed beyond the geographic limits of their local population. Fostering is most justified for breeding populations that have abnormally reduced productivity (e.g., birds affected by DDE-induced eggshell thinning) with smaller than normal broods. It is probably not justified as a management technique for populations that are reproducing normally, although experimental studies with artificially increased broods to determine the influence of brood size on rates of survival and development of young, and the limits of food provisioning by parents, would be interesting. In addition, the influence of supplemental feeding on survival of artificially enlarged broods would be useful to know and could have some application for management.

CROSS-FOSTERING. Like hacking, cross-fostering has the potential for re-establishing Peregrines in vacant range. To date it has been used most effectively in California, where Prairie Falcons now occupy cliffs and habitat formerly used by Peregrines (Walton and Thelander 1988). At 14 to 28 days old the young Prairie Falcons are removed from their eyrie and fostered elsewhere, and a brood of 14 to 17-day old Peregrines is substituted. The parent Prairie Falcons readily accept the fostered young and have no difficulty rearing them. Early fears that cross-fostered Peregrines might become abnormally imprinted or otherwise dysfunctional in their behavior as adults have not been borne out, as cross-fostered Peregrines have bred successfully in California both at territories reclaimed from Prairies and at other sites. Apparently, as long as young Peregrines are reared together in groups, they do not become sexually imprinted on the parent Prairie Falcons. It is wise to take a conservative approach by placing only two or three Peregrines into a cross-foster site (never only one). Peregrines eat a diet rich in bird species which not all Prairie Falcon parents provide. This technique could be applied advantageously in several other western states where Prairie Falcons now nest in suitable habitats for Peregrines. Cross-fostering requires observation of the Peregrine nests to assess age, and also several Prairie nests in order to have not only a recipient nest for the Peregrines, but also one or more for the displaced Prairies. Since Prairie Falcons often have five young, and recipient foster nests for them need to have fewer than that, it is necessary to know the status of several Prairie nests in the vicinity.

In Germany young Peregrines have also been successfully reared and fledged by Goshawks *(Accipiter gentilis),* Common Buzzards *(Buteo buteo),* and Common Kestrels *(Falco tinnunculus),* but it is unclear whether any of these cross-fostered Peregrines have survived to reproduce (Saar 1988). The tree-nesting species have been used as foster parents in an attempt to re-establish the lost tree-nesting populations of Peregrines that once existed on the Baltic plain of Germany and Poland. The technique could have some potential for re-establishing a tree-nesting population in the Mississippi River drainage system, or elsewhere in the USA, possibly by using the Red-tailed Hawk *(Buteo jamaicensis)* as the foster parent.

VIII. CONCLUSIONS

Tom J. Cade

What is to be said of the Peregrine Falcon in the final years of the Twentieth Century? It is no longer an endangered species in North America (Enderson et al. 1995). While this manual was being written, we have seen the northern *tundrius* race officially downlisted to "threatened" and finally delisted in 1994. In June of 1995 the U.S. Fish and Wildlife Service published a notice in the Federal Register to delist the *anatum* subspecies, and it is likely that the populations subsumed under that name will be officially removed from the list soon, or at least downlisted to "threatened".

We can thank this remarkable recovery of the Peregrine to the courage and determination of the first Administrator of the Environmental Protection Agency, William Ruckelshaus, who, against the ruling of his own hearing examiner and the intense lobbying of many pro-pesticide advocates, banned the use of DDT for nearly all purposes in 1972. This action, more than any other human intervention, made it possible for the surviving remnant populations in the wild to increase their numbers and reclaim vacated eyries throughout much of the former range. It also made possible the successful reintroduction of captive-produced falcons in southern Canada and the coterminous United States.

Managers need to remember the central role of DDT and other organochlorine pesticides (especially dieldrin) in the decline of the Peregrine Falcon, because there is now a tendency after 30 years of endangered status for some people to think of the Peregrine as a fragile species that will always require a lot of care and intensive protection. Like some other top predators, the Peregrine just happened to have a peculiar sensitivity to the eggshell thinning effects of DDE and, consequently, experienced profound reproductive impairment during the worst years of contamination, as well as probable increased mortality from the more potent compounds such as dieldrin.

Otherwise, historically the Peregrine was known to be a remarkably adaptable and resilient species, able to survive most of the "slings and arrows of outrageous fortune." From the Eighteenth Century right into the early decades of the Twentieth Century, the Peregrine was relentlessly persecuted by gamekeepers, gunhunters, egg and museum skin collectors, pigeon fanciers, and vandals of all sorts. These human enemies accounted for the destruction of many thousands of Peregrines and their eggs and young in both Europe and North America, but the falcon populations of these continents remained little changed by these human causes of death. Breeding populations, reflected by the number of occupied eyries, changed little over spans of time measured in decades and centuries, except for localized regions where human uses of land reduced the abundance of prey below densities that can sustain nesting falcons or made specific eyries unacceptable.

The explanation for this population resilience lies in the widely spaced pattern of breeding dispersion adopted by pairs and in the production of a reserve of adults above the number that can find places to nest within the rather rigid, territorial system. These surplus adults — or "floaters" — are available to replace lost or moribund breeders rapidly at the eyries. In a healthy Peregrine population that is at the environmental carrying capacity for number of pairs, these floaters may equal or exceed the number of breeders, depending on the rate of reproductive success and survivorship (Hunt 1988, Newton 1988). The importance of floaters in Peregrine population dynamics has not received as much recognition among biologists and managers as it deserves, and we still need to develop more direct ways to study this segment of the population.

Because of this population resilience to natural causes of mortality and the continent-wide reductions in the use of organochlorine pesticides, the foreseeable future of the Peregrine looks bright. The species has reclaimed most of its original distribution and abundance in the boreal and arctic regions of Greenland, Canada, and Alaska, and throughout much of the western United States as well, particularly in California, Arizona, Utah, Colorado, and New Mexico, as well as farther south in Mexico. In these less human-populated regions, little or no hands-on management should be needed in the future. Occasional surveys or inventories of eyries in selected regions should be sufficient to keep managers aware of general trends in population dynamics and viability.

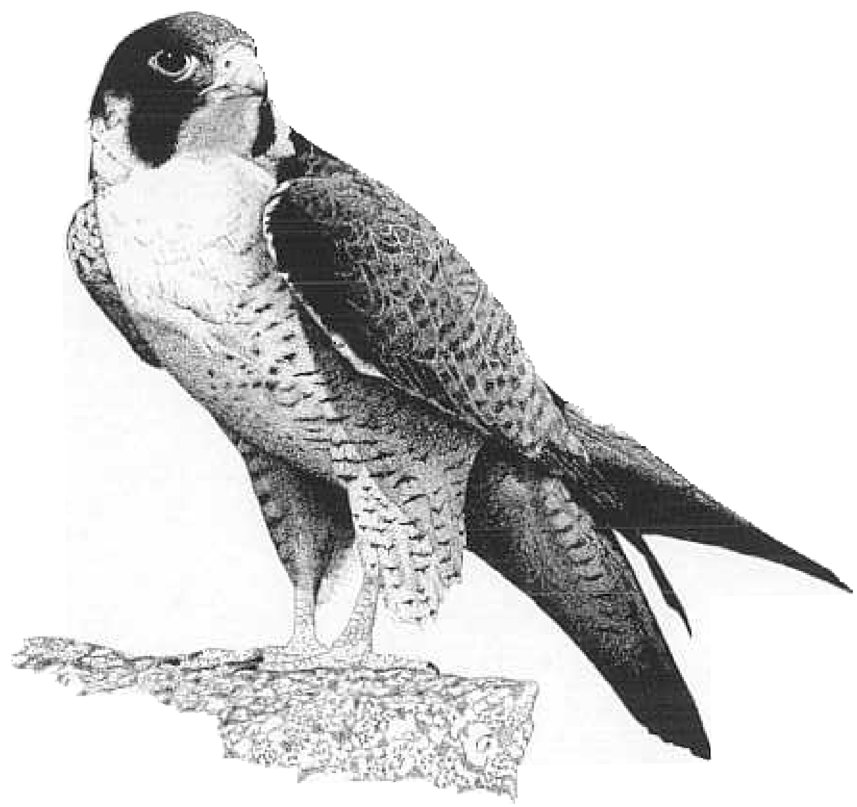
In addition, captive propagation has made it possible to ensure a continuing supply of birds for falconry as well as for reintroduction where locally desirable (Cade in press). The techniques of reintroduction make it possible to establish nesting Peregrines virtually anywhere humans want them. One of the surprising aspects has been the ease with which captive-reared and released falcons have adjusted to new and novel environmental situations, as shown by their acceptance of man-made structures as nest sites and willingness to live and breed in urban settings. Today Peregrines nest on skyscrapers, church steeples, bridges, decommissioned ships, silos, power plant smokestacks, and on specially constructed nesting towers. In 1993 at least 88 pairs of Peregrines were present in 60 urban areas of Canada and the United States (Cade et al. 1995), and the number has continued to grow.

What more should be done? Peregrines still need some special care in eastern North America, where the re-established population has only a limited but so far encouraging hold on the land. The species could use more help in the northern Great Plains, where further releases could increase the still diminished number of nesting pairs, and the falcons in California should be watched carefully over the next five years to make sure they can produce enough offspring to maintain existing numbers and to increase in the face of continuing chemical contamination of their environment, without further augmentation with released birds. The same is true for parts of eastern North America. Complacency has no role in the modern world: We had better be prepared to anticipate new and unexpected hazards for Peregrines in the future, as well as to make doubly certain the old problems are truly gone.

Locally, management should include maintenance and improvement of nesting sites. At man-made locations these actions will include maintaining and building towers and removal of other species (owls) using the sites. On buildings and bridges, construction or replacement of nest boxes will be needed from time to time, as well as some coordination of structural maintenance schedules to reduce conflicts with the falcons' breeding season. Where pairs experience poor reproduction or failure at natural eyries, nest ledges on cliffs can be modified to

improve breeding success by enlarging ledges, adding better substrate, increasing drainage, and reducing access by predators; or superior, new sites can be constructed on the cliff to replace poor ones.

Additional management may need to include monitoring human activities in the vicinity of eyries, particularly in areas of high use by hikers, rock-climbers, photographers, and sightseers. Seasonal restrictions on climbing and trail-closures may be necessary in some places, but the draconian regulations that have been imposed on human access to Peregrines and Peregrine habitats in Great Britain (Ratcliffe 1993) should not be necessary in North America and probably would not be tolerated by the American public.



Literature Cited

Brown, B. T., G. S. Mills, R. L. Glinski, and S. W. Hoffman. 1992. Density of nesting Peregrine Falcons in Grand Canyon National Park, Arizona. Southwestern Naturalist 37:188-193.

Burnham, W. A. 1983. Artificial incubation of falcon eggs. Journal of Wildlife Management 47:158-168.

Burnham, W. A., J. H. Enderson, and T. J. Boardman. 1984. Variation in Peregrine Falcon eggs. Auk 101:578-583.

Burnham, W. A., W. Heinrich, C. Sandfort, E. Levine, D. O'Brien, and D. Konkel. 1988. Recovery effort for the Peregrine Falcon in the Rocky Mountains. Pp. 565-574 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Cade, T. J., 1960. Ecology of the Peregrine and Gyrfalcon populations in Alaska. University of California Publications in Zoölogy 63:151-290.

Cade, T. J. (in press). Birds of Prey (Falconiformes). *in* The economic use of wildlife resources (H. H. Roth and G. Merz, Eds.). Springer Verlag, Berlin.

Cade, T. J., J. H. Enderson, C. G. Thelander and C. M. White (Eds.). 1988. Peregrine Falcon populations, their management and recovery. Boise, Idaho, The Peregrine Fund.

Cade, T. J., and D. M. Bird. 1990. Peregrine Falcons, *Falco peregrinus,* nesting in an urban environment: a review. Canadian Field-Naturalist 104:209-218.

Cade, T. J., and C. G. Jones. 1993. Progress in restoration of the Mauritius Kestrel. Conservation Biology 7:169-175.

Cade, T. J., M. Martell, P. Redig, G. Septon, and H. Tordoff. 1996. Peregrine Falcons in urban North America. Pp. 3-13 *in* Raptors in human landscapes (D. M. Bird, D. E. Varland, and J. J. Negro, Eds.). Academic Press Ltd., London, and The Raptor Research Foundation.

Conway, C. J. , S. H. Anderson, D. E. Runde, and D. Abbate. 1995. Effects of experimental nestling harvest on Prairie Falcons. Journal of Wildlife Management 59:311-316.

Cramp, S., and K. E. L. Simmons (Eds.). 1980. The birds of the western Palearctic, vol. 2. Oxford, Oxford Univ. Press.

Crick, H. Q. P., and D. A. Ratcliffe. 1995. The Peregrine *Falco peregrinus* breeding population of the United Kingdom in 1991. Bird Study 42:1-19.

Ellis, D. H. 1982. The Peregrine Falcon in Arizona: habitat utilization and management recommendations. Oracle, Arizona, Institute for Raptor Studies Research Report No. 1.

Enderson, J. H. 1969. Peregrine and Prairie Falcon life tables based on band-recovery data. Pp. 505-508 *in* Peregrine Falcon populations: their biology and decline. (J. J. Hickey, Ed.). Madison, University of Wisconsin Press.

Enderson, J. H., G. R. Craig, W. A. Burnham, and D. D. Berger. 1982. Eggshell thinning and organochlorine residues in Rocky Mountain peregrines *(Falco peregrinus)* and their prey. Canadian Field Naturalist 96:255-254.

Enderson, J. H., and G. R. Craig. 1988. Population turnover in Colorado Peregrines. Pp. 685-688 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Enderson, J. H., C. Flatten, and J. P. Jenny. 1991. Peregrine Falcons and Merlins in Sinaloa, Mexico, in winter. Raptor Research 25:123-126.

Enderson, J. H., W. Heinrich, L. F. Kiff, and C. M. White. 1995. Population changes in North American Peregrines. Pp. 142-161 *in* Transactions of the 60th North American Wildlife and Natural Resources Conference. Washington, D.C. Wildlife Management Institute.

Enderson, J. H., J. Larrabee, Z. Jones, C. Peper, and C. Lepisto. 1995. Behavior of Peregrines in south Texas. Raptor Research 29:93-98.

Frank, S. 1994. City Peregrines. A ten year saga of New York City falcons. Hancock House Publishers, Ltd. Surrey, British Columbia.

Fyfe, R. W., R. W. Risebrough, J. G. Monk, W. M. Jarman, D. W. Anderson, L. F. Kiff, J. L. Lincer, I. C. T. Nisbet, W. Walker II, and B. J. Walton. 1988. DDE, productivity, and eggshell thickness relationships in the Genus *Falco.* Pp. 319-335 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Hickey, J. J. 1942. Eastern population of the Duck Hawk. Auk 59:176-204.

Hickey, J. J. (Ed.). 1969. Peregrine Falcon populations: their biology and decline. Madison, Univ. of Wisconsin Press.

Hunt, W. G. 1988. The natural regulation of Peregrine Falcon populations. Pp. 667-676 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Hussong, H. H. 1993. Peregrine propagation and release in Germany. The Journal of the North American Falconers' Association. 32:32-36.

Mearns, R., and I. Newton. 1984. Turnover and dispersal in a Peregrine *Falco peregrinus* population. Ibis 126:347-355.

Nelson, R. W. 1988. Do large natural broods increase mortality of parent Peregrine Falcons? Pp. 719-728 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Newton, I. 1979. Population ecology of raptors. Berkhamstead, England, T & A D Poyser.

Newton, I. 1988. Population regulation in Peregrines: an overview. Pp. 761-770 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Nielsen, O. K., and G. Petursson. 1995. Population fluctuations of Gyrfalcons and Rock Ptarmigan: analysis of export figures from Iceland. Wildlife Biology 1:65-71.

Nisbet, I. C. T. 1992. Predation by a Peregrine Falcon on Common and Roseate Terns on Bird Island. Bird Observer 20:137-139.

Nye, P. E. 1988. A review of Bald Eagle hacking projects and early results in North America. Pp. 95-112 *in* Proceedings of the International Symposium on Raptor Reintroduction, 1985 (D. K. Garcelon and G.W. Roemer, Eds.). Arcata, California, Institute for Wildlife Studies.

Paine, R. T., J. T. Wootton, and P. D. Boersma. 1990. Direct and indirect effects of Peregrine Falcon predation on seabird abundance. Auk 107:1-9.

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature 215:208-210.

Ratcliffe, D. A. 1988. The Peregrine population of Great Britain and Ireland, 1965-1985. Pp. 147-157 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Ratcliffe, D. A. 1993. The Peregrine Falcon. Second Edition. T & A D Poyser, London.

Rohlf, F. J. and R. R. Sokal. 1981. Biometry: The principles and practice of statistics in biological research. W. H. Freeman, New York.

Saar, C. 1988. Reintroduction of the Peregrine Falcon in Germany. Pp. 629-635 *in* Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Sherrod, S.K. 1983. Behavior of fledgling Peregrines. Ithaca, New York, The Peregrine Fund.

Sherrod, S. K., W. R. Heinrich, W. A. Burnham, J. H. Barclay, and T. J. Cade. 1981. Hacking: a method for releasing Peregrine Falcons and other birds of prey. Fort Collins, Colorado, The Peregrine Fund.

Walters, R. 1995. The falcons of Salt Lake City, Utah. Information Circular, Utah Division of Wildlife Resources.

Walton, B. J., and C. J. Thelander. 1988. Peregrine Falcon management efforts in California, Oregon, Washington, and Nevada. Pp. 587-597 in Peregrine Falcon populations, their management and recovery (T. J. Cade, J. H. Enderson, C. G. Thelander, and C. M. White, Eds.). Boise, Idaho, The Peregrine Fund.

Weaver, J. D., and T. J. Cade (Eds.) 1991. Falcon propagation: a manual on captive breeding. Revised. Boise, Idaho, The Peregrine Fund.

White, C. M. and S. K. Sherrod. 1973. Advantages and disadvantages of the use of rotor-winged aircraft in raptor surveys. Raptor Research 7:97-104.