RAPTOR RESEARCH NEWS

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Editors: Donald V. Hunter, Jr. Centerville, S. Dakota
Byron E. Harrell, University of South Dakota
Vermillion, South Dakota

EDITORS' NOTES

With this final issue of the year we hope we have presented material of interest and value to our readers. We believe you will join us in thanking those who have written material for the News.

The Editors want to urge all of you to consider the preparation of short notes or long articles for next year's issues of Raptor Research News.

MEMBERSHIP POLICY

The membership of the Raptor Research Foundation is made up of the Board of Directors, the Advisory Board, and Associate Members. All who are interested in raptors are welcome to Associate Membership on contribution of money for a calendar year.

The volume of the material used in the News this year was greater than anticipated by the Editors and the cost of producing and mailing four issues greater than the $1.00 minimum contribution. For this reason and for some other planned developments in the News the Board of Directors has recently voted to increase the minimum to $2.00 which is the anticipated cost for the next four issues mailed.

This minimum contribution has been set as low as possible so that no one need be excluded; the Board of Directors had students particularly in mind. However, all other activities beyond the News are financed by the generosity of individuals beyond this minimum. The Board hopes that you will consider our needs when you receive a renewal statement in the near future.

ADVISORY BOARD

Members of the Advisory Board were listed in the last two issues of the News. The Editors wish to apologize for misspelling the name of Mr. and Mrs. Stickel and for not catching the omission of Lt. Col. James McIntyre, USAF Academy in Colorado. Mr. Richard Fyfe has transferred to Edmonton, Alberta. The Advisory Board now has 23 members and is fairly representative of various interests in raptors in North America.

RAPTOR RESEARCH FOUNDATION COMMITTEES

A committee structure of the Foundation is being developed. We intend to announce the appointments to the committees and their proposed activities in the first issue next year. We hope that these developments will expedite and expand the influence of the Foundation.

ON THE USE OF FAULT BARS IN AGING BIRDS OF PREY

Mrs. Frances Hamerstrom has recently published a short article on this topic in Inland Bird Banding News (Vol. 39, pp. 35-41, 1967). She has a small supply of reprints which should be of special interest to raptor banders.

RAPTOR BREEDING PROGRAM

We are happy to include a major report in this area by Frank Beebe later in this issue, but we have a few short notes of information here.

Mr. Kerry A. Muller of the Bird Division of the National Zoological Park in Washington, D.C., reports that their Rufous-thighed Falconets (Indian) had two infertile eggs, their Collared Forest-falcons laid an egg which fell and broke, and that an Elf Owl was raised this year.

The B.P.I.E. (Breeding Program Information Exchange) had a slow start but issues came out in October and November. B.P.I.E. No. 1 contained information from Don Hunter and Richard Olendorff. Hunter discusses his breeding plans for Peregrines, Gyrfalcons, American Goshawks, Red-tails, and American Kestrels. For these he raises his own food, 4-6 week old chicks. He describes the quarters and some past experience with light manipulation. His birds have had no foot trouble; he feels foot trouble is not due to hard perches, but to hitting the hard ground at the end of a leash while tethered. He recommends covering the perches of tethered birds with material from door mats with raised bristles of molded rubber. Olendorff gives a full account of a breeding attempt in 1966 with a pair of eyas American Kestrels; while the attempt was unsuccessful, the detailed information provides useful ideas for other breeding program workers.

Ryan Walden has a report in B.P.I.E. No. 2 of the facilities and plans of the Academy of Natural Sciences in Philadelphia aimed at breeding Harris's Hawks, Red-tails, Swainson's Hawks, and Prairie Falcons.

NORTH AMERICAN NEST-RECORD CARD PROGRAM

The News printed an announcement of this program earlier (Vol. 1, No. 2, p. 21). We want to remind our readers who sent for cards to send them in, or if you did not and you have data on old or new active nests in your records, send for cards and return them to

North American Nest-Record Card Program
Cornell Laboratory of Ornithology
33 Sapsucker Woods Road
Ithaca, New York 14850.

SPECIAL REVIEW--MARSHALL ON SCREECH OWLS

by Byron E. Harrell

Marshall, Joe T., Jr.--"Parallel Variation in North and Middle American Screech-owls." Monographs of the Western Foundation of Vertebrate Zoology No. 1, 72 pp., frontispiece, 31 figures, 1967. (Available for $3.50 from Western Foundation of Vertebrate Zoology, C. V. Duff, Business Manager, 1100 Glendon Ave., Los Angeles, California 90024.)

The genus Otus is widespread and is divided into numerous species. To the ornithologist who has had to make taxonomic decisions on the basis of small samples it is a confusing and difficult genus. At last for North and Middle America one can turn to this excellent account in which one can see the reasons for earlier confusion. Since much confusion arose from worn-plumaged birds or from post-mortem changes, Marshall had to base most of his work on newly collected birds in fresh plumage. At the same time he collected much information on habitat, voice, and certain aspects of behavior. Tape recording and sonograms added essential data.

Marshall places the 27 forms he recognizes into seven species: Otus asio (14 subspecies in four groups), O. trichopsis (3 subspecies), O. flammeolus, O. choliba, O. guatemalae (4 subspecies), O. barbarus, and O. clarkii. The four groups of Common Screech Owls approach the level of full species; he recognizes that others would split them. His full discussion allows the reader to judge for himself. One of the many interesting evolutionary conclusions is that character displacement has had no role in racial adaptation. Indeed the opposite occurs, for convergence in coloration is quite common. Parallelism, as indicated by the title, is very important in this genus.

Treatment of each form and abundant discussion make up about half of the large size pages (about 23 x 30 cm). There are 20 pages of specimen photographs, diagramatic representation of sonograms, sketches of feet, sketches of feathers which show color patterns in different forms, a synopsis, a table of synonyms, comments on type specimens, some important suggestions on specimen preparation, and maps, as well as an index. The colored photograph frontispiece is delightful.

The style is more informal than usual in taxonomic papers, but the language is vivid and descriptive and the anecdotes amusing and pertinent. One minor point is my personal dislike of the form of common name as Screech-owl, which however is preferable to the alternative he had considered of Scops-owl. He does not justify this orthography which I feel detracts from the handy lumping of all owls in indexes under one term. Joe Marshall's long time interest in owls and his extensive travels studying them have made one of the most interesting taxonomic papers in a long time.

BALD EAGLE - OSPREY STATUS REPORT, 1967
CHIPPEWA NATIONAL FOREST, MINNESOTA

by John E. Mathisen
Wildlife Biologist, U.S. Forest Service

Bald eagle and osprey populations of the Chippewa National Forest have been evaluated for the fifth consecutive year. The inventory of nest sites has continued with the cooperation of Ranger District personnel and the Bureau of Sport Fisheries and Wildlife. An attempt was made to observe as many nests as possible in early spring to determine occupancy. Occupied nests were again checked in midsummer to determine nesting success. A nest was considered active if adults were present, or if droppings indicated substantial use of the nest tree. If young were present in late June or July, the nesting attempt was considered successful.

New Nests and Nest Losses. Another effort was made to locate eagle and osprey nests from aircraft in cooperation with the Bureau of Sport Fisheries and Wildlife during the week of March 13 through 17, 1967. The northern half of the Forest was given special attention. Approximately 13 hours flying time were utilized in the search. The survey was very successful with 46 additional nests being located (26 eagle nests, 20 osprey nests). The find rate was 3 1/2 nests per hour of flying time.

A total of 39 eagle nests and 29 osprey nests was added to the records in 1967. Nine eagle nests had blown down, and two were considered abandoned, which brings the total number on the Forest to 135. We now have a total of 59 osprey nests on the records, with many more yet to be located.

Nesting Success. Sixty-seven of the eagle nests were observed at least once during the 1967 breeding period. Forty-nine, or 73% were considered to be active (occupied by adults at time of observation). Thirty-eight were checked for young, indicating a nesting success of 55%. This was somewhat less than nesting success for 1966, but still well above average for the five-year period. The outcome of the other 68 nests is not known, but an estimate can be calculated by projecting data for known outcome nests. The following table summarizes results of the 1967 breeding season.

District	Known Nests	Observed Nests	Active Nests	Successful Nests	Number of Young
Bena	35	20	17 (3)*	5	8
Blackduck	11	5	6 (5)	1	2
Walker	12	6	2 (2)	1	1
Remer	8	3	2 (0)	0	0
Marcell	10	5	4 (3)	3	4
Cass Lake	32	15	8 (7)	5	7
Cut Foot Sioux	27	13	10 (8)	6	8
FOREST TOTAL	135	67	49 (38)	21	30
Percent		50%	73%	55%	1.4/nest
PROJECTED FOREST TOTAL			99	54	76

*() indicates number of active nests observed in summer, used for calculating % of successful nests.

The following table compares eagle nesting data on the Chippewa for the past five years.

Year	Known Nests	Observed Nests	Active Nests* No.	Active Nests* %	Successful Nests No.	Successful Nests %	Young per Nest
1963	48	31	20	64	6	30	1.7
1964	55	46	30	65	12	40	1.2
1965	76	58	39	67	22	56	1.3
1966	107	70	52	74	19	61	1.5
1967	135	67	49	73	21	55	1.4

* Only active nests with known outcome were used for calculating nesting success.

Other Observations. An analysis of nesting success data from 1963-1966 clearly showed that eagle nests located in extremely isolated areas were no more successful than those in areas of frequent human presence. This material was accepted for publication and will soon appear in the Journal of Wildlife Management.

Of special interest this year was the frequent observation of sub-adult eagles prior to fledging. In previous years it was considered rare to observe a sub-adult eagle on the Chippewa, 2 or 3 observations being usual. Nineteen sub-adults were observed this year by the Forest Biologist.

Eight nestlings were banded by Dr. Al Grewe and a student assistant (this brought the total nestlings banded to 10). Three and possibly four adult mortalities were reported, two by shooting, the others by unknown causes.

Osprey Nests. Twenty of the fifty-nine osprey nests were observed for occupancy. Seventeen, or 85% were considered active. Nine of the active nests were checked for success, and all but two contained advanced young. This indicates that ospreys on the Chippewa are not suffering from reproductive failure. More effort should be placed on evaluating osprey nesting activity.

BRIEF REPORT ON A HARRIER POPULATION STUDY IN CENTRAL WISCONSIN

by Frances Hamerstrom
Plainfield, Wisconsin

An average of over three observers worked on this project daily from June 6 through August 16; the observers were Frances Hamerstrom, Wayman Walker, and others. Three aspects of the study were emphasized:

1. Nest finding.
2. Trapping of harriers for individual study and biopsy.
3. Census.

We were only able to find three nests on the 40,000 acre study area and are confident that no other nests brought off young.

In spite of intensive efforts, we caught only six individuals (successful summer trapping is almost exclusively geared to defense of nests). There were forty potential breeders on the study area: 20 males and 20 females; thus we had the potential population for 20 (rather than three) nests. The nesting population has dropped from 25 nests in 1963 to three nests in 1967.

This is a sad report to make. We hear the hum of spray planes almost daily during the growing season. We do not know whether there is a correlation between pesticides and our almost non-producing harrier population. Biopsies were taken from the six harriers caught (4 breeders and 2 non-breeders). Analyses of these biopsies may give us a clue. We have no evidence that either marking or biopsy adversely affected any individual.

EXPERIMENTS IN THE HUSBANDRY OF THE PEREGRINE

by Frank L. Beebe
Saanichton, B.C.

The purpose of this paper is to outline the progress that has been made, to date, toward the goal of the domestication of the Peregrine (Falco peregrinus). As a wild species, the Peregrine seems to be greatly menaced by certain aspects of modern civilization. The exact nature of the combination of forces that have brought entire populations in widely separated parts of the world to near extinction are not completely known and will probably never be known unless a domestic-bred population can be produced for controlled research.

The almost simultaneous decline of such widely separated and distinct populations as that of the eastern North American race known as the Duck Hawk; the ground-nesting population of the Finland bogs; the tree-nesting population of the countries bordering the southern Baltic, and both the inland and coastal populations of Great Britain, was documented at the International Conference on the Population Biology of the Peregrine Falcon held at Madison, Wisconsin in August and September of 1965. At that time circumstantial evidence was presented that the widespread use of agricultural and silvicultural poisons of the chlorinated hydrocarbon group was responsible for the decline in some areas. This evidence was particularly strong in relation to the British, Finnish, and Baltic populations but less convincing in relation to the Alpine population of central Europe, the population of coastal Scandinavia, the eastern North American population, the canyon-breeding Peregrines of the western United States, and the riverine population of western Canada. The British studies (Ratcliffe, D.A., Bird Study, 12:66-82, 1965) do however show that the Peregrine is a very good indicator species of environmental contamination and as such is eminently suited to research in this field, especially in studies relative to the possible effects of accumulated contaminants on reproduction (Moore, N.W., Bird Study, 12:222-252, 1965).

However, the type of intimate studies relative to reproduction that are most needed are also the most difficult to undertake if based on wild populations under field conditions. Studies of what are apparently already weakened or dying populations are likely to be rather meaningless for the above purpose, especially when the interference factor inherent in such field studies of disturbance-sensitive species is taken into consideration. Field studies of the two large and apparently healthy North American populations of the arctic and northwest coast are extremely difficult and expensive due to the remote and climatically hostile regions in which these populations are located. The availability of healthy Peregrines of domestic origin could be of great value in studies aimed at accurate evaluation of contamination levels if such stock could be produced.

The main orientation of the author, however, is not in the foregoing direction. Regardless of the cause or causes of the decline of the Peregrine, it is quite possible that in the future birds directly from the wild will not be available for falconry. For this reason the author initiated his work on the domestication of the Peregrine in cooperation with other interested individuals.

Acknowledgments

The continuing experiment, of which the subject matter of this paper is but a beginning, has been made possible by the help of many people and institutions. To Raptor Research Foundation, of Centerville, South Dakota, must go the credit for co-relating the work and providing background data. The Canadian Wildlife Service has provided some of the birds involved in the current program, these being some of the falcons which were originally collected for the National Research Council relative to clearing gulls from the vicinity of airports. The British Columbia Fish and Wildlife Branch has ensured the continuity of the program by providing special permits to take young Peregrines for the project. The British Columbia Provincial Museum, with which institution I am employed, has provided the time and has paid my personal expenses on the expeditions to obtain birds while the Federal Fisheries Department has provided the large seagoing vessels, complete with crew, that made collecting possible along the west coast of the Queen Charlotte Islands. David Hancock, who collected the Research Council birds, also made the photographic record, in movies and stills, of the nesting attempts (including the four photographs reproduced in this paper).

Egg-laying by Captive Raptors

Although falconers have handled and flown Peregrines for some two thousand years, the husbandry of the species does not seem to have been attempted until modern times. Most of the traditional procedures of handling and caring for hawks and falcons have mitigated against any attempt by the birds to reproduce once removed from the wild population. Possibly foremost among these is the traditional concept of capturing birds for falconry only after they can fly well and have learned to hunt. Such birds, while they can be trained rather easily and tamed to a limited degree, are yet never entirely relaxed in the semi-captive situation. Similarly, when nestlings (known to falconers as eyasses) were taken, the traditional methods of keeping these were no better oriented toward reproduction than were those of the wild-caught birds. They were always taken when nearly ready to fly and then made as much like the wild-caught birds as possible by a period of free-flying known as "hack." These traditions have led to a further tradition that a high incidence of loss is to be expected, and comparatively few eyas birds have been kept long enough to reach reproductive age. Fewer yet of these have had any access to natural mates. Traditional falconry has been strongly oriented toward the use of the females. The males, mostly because of their smaller size, received comparatively little attention and were seldom taken if females were available.

Nevertheless in the recent history of falconry there runs a situation under which apparently unmated females occasionally produce eggs. These birds have a remarkably similar history and background. To my knowledge they have been, without exception, birds that have been taken from the nest much younger than traditionally advised, usually as downies. Generally speaking, such birds have been kept in a specific place or building over a period of three years or longer, and if flown at all this has been done over a limited, and familiar, terrain most or all of this time. In addition, these birds have usually been handled almost entirely by one individual. Sometimes years before eggs are produced there are indications of a pair-bond being formed with the human, for such birds greet the appearance of the human "mate" with the sounds characteristic of the species when calling to the natural mate, accompanied by the same bowing and rotating ceremonials that occur with mated pairs. When eggs eventually are produced, and sometimes long before, the birds become extremely hostile to all humans except the one individual.

If a nest-ledge is provided and eggs are laid, such birds generally become so preoccupied with incubation as to be unconcerned about their own health and discomfort. Lacking a natural mate to relieve them on the nest, they cover the eggs continuously, day and night, scarcely leaving them long enough to eat. Later, if young of their own, or even of a different species, are substituted for the eggs, these adults will at once adopt, feed, and defend them. What such birds usually will not do is accept a natural mate at any time, and males of their own species that are introduced into their territory are usually attacked at once and may even be killed. It is the fairly regular occurrence of these egg-laying birds that has caused falconers to consider the possibility of the husbandry of some of the rarer raptors. It should be pointed out that many species have been involved in this type of behaviour. To my knowledge females of the Golden Eagle, European and American Goshawk, Red-tailed Hawk, Peregrine, and Prairie Falcon have all laid eggs under the foregoing circumstances, and there are probably others. If they have done nothing else, these birds have clearly indicated that the female of a number of species of raptorial birds needs little exercise and very little space to remain in good health and to come into reproductive capability, for many have been very closely confined. Indeed, the evidence suggests that only very well-fed, sedentary females of many of the large raptors are capable of ovulation.

There are some instances of some of the larger raptorial birds reproducing in zoos. The vultures and owls quite regularly reproduce in the zoo environment, as do some of the smaller falcons, most notably the kestrels. Certain species of the buteoine hawks have also, less commonly, reproduced in zoos. So too have several species of eagles. Possibly the large falcons and some of the accipiters might also have done so by this time were these groups more adaptable to the confinement provided by screened enclosures, but most species in these genera have a reputation of being almost useless as public exhibit due to their habit of repeatedly flying at high speed into the restraining mesh. In recent years some of the more

progressive of modern zoos have attempted to show these birds by leashing them to lawn-blocks in the same way that falconers have traditionally kept their birds. Such an arrangement does permit the exhibit of these species, but of course gives them no opportunity to reproduce.

Prior Attempts at Captivity Breeding

There are verbal reports of some attempts to breed Peregrines in Hungary between the two world wars but the first documented account is the series of experiments by Renz Waller in Germany during the Second World War, and no report of similar experiments with Peregrines can proceed without reference to his work. The account has been published in the book "The Wild Falcon Is My Companion" and that portion relating to the breeding experiments has been translated into English by Erling Sundve and Ronald Stevens.

The reported experiment extended over a period of some eight years and concerned both Peregrines and Goshawks, but it is only to the former that I shall refer here. The entire sequence with the Peregrines involved only three individuals, one female and two males. The year the first nesting attempt was made is not definitely stated, but it would appear to be in 1938 or 1939. The female was about five years of age. The pair was confined in an aviary 15 feet long, 9 feet broad, and 6 feet high. Two eggs were produced, the first on the 21st of March. Both sexes took part in incubation but the eggs failed to hatch. No information is given as to whether the eggs were fertile or not, nor is there any information on the background of the two birds, but there is an unstated implication that they were both eyasses. After full-term incubation, two large downy Buzzards were placed in the nest and the eggs were removed. The young Buzzards were ignored but not molested by the female, were fed by the male for fourteen days, then abandoned.

The same pair made a second nesting attempt the following year in the same aviary. Again the eggs failed to hatch. This time one of the eggs was opened and a well-developed, dead embryo was found. No information on the treatment of the two adults in the time interval between these two attempts is given, nor are the dates of egg production.

The third attempt occurred in 1941. The female was the same bird that attempted the two previous nestings, but she had been moved to a different place and a different setting. The quarters this time are described simply as "a room," the dimensions not given, but the pair seems to have been quite closely confined. The new male was an injured, wild-caught adult of unknown age. Three eggs were laid between the 10th and 15th of March and were brooded by both sexes until the 20th of April but failed to hatch. The eggs were removed, checked, and found to be infertile.

In the spring of 1942 the fourth reproductive attempt was made by this falcon in company with the same wild-caught male. Four eggs were laid between the 5th and 13th of March when temperatures were as low as 20 degrees below zero. Both sexes again took part

in incubation. One egg was accidentally broken on the 19th of March, but two of the three remaining eggs subsequently hatched on the 12th of April. The third egg failed to hatch but on examination proved to contain a full-term chick that had died in the egg. One of the two successfully hatched young died on the 27th of April, but the one remaining young bird was brooded, fed, and normally attended by both adults until the 8th of May at which date it was taken from the adults and reared to flying age by the falconer.

One more successful nesting was made by the same pair in the spring of 1943. Eggs were produced unusually early--the first on the 25th of February, the third and last on the 3rd of March. Incubation proceeded normally as before, but only one egg hatched. One egg contained a large dead embryo; the third egg was infertile. The young falcon was left with the adults and was attended normally until the 7th of May, then removed. This bird too was raised to flying age successfully.

Waller's experiments terminated at this point, his entire property being destroyed by air-raids although he notes that the hawk-shed escaped damage. Waller's conclusions: (1) work only with birds held for a long time in captive situation; (2) feed a rich diet; (3) absolute seclusion to copulation.

Following Renz Waller's experiments, there seems to be no further recorded attempt to raise Peregrines until 1959 when Ronald Stevens began a similar program in Ireland extending over a period of four years. Stevens has published a full account of the two nesting attempts by his pair in the Journal of the North American Falconers Association of 1963. In this case both birds are clearly stated to have been eyasses, and, in 1959 when they were first confined together, the female was seven years old. The male was of doubtful maturity, being only two years of age. Stevens' pair was given considerable space, being confined in a building measuring 40 feet by 18 feet by 16 feet. There was no attempt at nesting in 1959, yet both sexes brooded and fed a young Merlin that was placed on the nest ledge. Again, in 1960 no eggs were laid and yet again the adult Peregrines brooded and attended two young Merlins that were placed on the nest ledge. In 1961 three eggs were produced, apparently early in April. Both sexes took part in incubation for a time, then one egg was found broken, and shortly after that the other two eggs "disappeared," apparently without trace. In 1962 three eggs were again produced, the dates not listed. These eggs were abandoned by the adult birds after the eggs had rolled into a deep crack in the dried turf on the nest-ledge. Finally, in 1963 two eggs were laid and were incubated by both sexes for four weeks. These eggs proved to be infertile.

Concurrent with Stevens' experiments, there have been several other unpublished attempts to attain domestic reproduction of Peregrines but apparently no eggs have been produced. It seems that the birds involved in most, if not all of these are wild-caught.

The Raptor Research Experiment at Saanichton, B.C.

A continuing series of experiments aimed at the domestication of the Peregrine was begun in 1965 by a team of cooperators programmed under the Raptor Research Foundation. Even with the initial pair the entire background of both birds is known and documented. Also, it is the first time where a continuing supply of young birds of known origin and background are being raised and conditioned for replacements and the setting up of new pairs at widely-separated points across the continent. The pair with which this paper is concerned, therefore, represents but the first nestings by the first pair that has been assigned to, and as much as possible conditioned for, a continuing series of experiments. In this case an obvious pair-bond had been formed and inasmuch as the female produced her first set of eggs by the third year, some of the conditioning techniques that were used should be recorded.

The pair of Peregrines now under discussion consisted of two of eight young of the race pealei taken from the east side of Moresby Island of the Queen Charlotte Islands group in June of 1963. Four males and four females were taken. The females were originally obtained specifically to be trained to attack large gulls in an experiment undertaken for the National Research Council of Canada. Nevertheless, during their first autumn and winter, two of the males were trained and kept with the four females much of the time. While kept leashed to blocks in the traditional manner, which of course does not permit any physical contact between individuals, much of the time they were either in the same room or in close proximity to one another on the lawn-perches. During the two seasons that the four females were flown to gulls, three of them met with accidents and were either killed or otherwise lost. The flights to gulls were terminated at the end of March, 1965. At this time the one remaining female was assigned to my care for the Raptor Research Foundation domestic reproduction experiments. This falcon then, and her mate, both had a very similar and well-documented background. Both had been lure-trained from July to September of 1963. The female had then been flown to gulls from September 1963 until April 1964. The male had been ill from an unknown cause during part of this time, from about September until late January, but had recovered and was being flown to domestic pigeons from January 1963 until March of 1964. The initial training of both birds took place over a hundred-acre saltmarsh some twelve miles north of Victoria, British Columbia. The flights to gulls by the female occurred at random over a much larger area, but never more than eight miles from the original training area. Due to considerable damage to the flight feathers in the numerous encounters with gulls, the female of the pair was not flown during her first moult, and was accordingly not flown from early April until mid-July. The male however was flown to lure and pigeons over the training area through the first moult.

After the 15th of July, and before the flights to gulls were again resumed, the two birds were flown together as a pair for a few times but the female proved to be intolerant of the male in

this situation and these flights were abandoned. She was subsequently flown to gulls for the second season, from October 1964 until the 10th of March of 1965. The male was also regularly flown to lure or to pigeons primarily over the training area. Throughout all this time neither of these birds was exclusively handled by any one person. As many as six different individuals, both men and women, handled them at different times and for widely varying periods of time. No strong association to any one person was therefore made by either bird.

With the cessation of the flights to gulls, and beginning just before the vernal equinox of 1965, the first steps of purposeful pre-conditioning toward eventual pair formation were begun. The two birds were confined together in a compartment of a building that was located on the saltmarsh training ground and from the windows of which much of the area could be seen. The room was not large, measuring only 12 feet by 18 feet by 8 feet, the long axis oriented east and west. Inasmuch as cold weather comes to this area from the northeast and major gales from the southeast, the room had glass windows protected by vertical slats on the north and east walls. The south wall was a featureless partition except for the door to the adjoining room, while the west wall was a continuous open, slatted window beginning some four feet from the ground and carried on up to the roof. Shelf perches were provided at the base of all windows and a pole perch joined north and south walls midway in the room. A small bath, raised some two feet from floor level, was placed against the south wall clear of all perches and a turf-covered nest ledge 2 feet by 4 feet was located some 6 feet above the floor in the northeast corner. The floor was of natural sandy earth covered with about two inches of western hemlock sawdust.

Although the female had never shown the least hostility to this male except when free in the air together, the precaution was taken of tethering the female to a lawn-block set adjacent to the bath for the first week. During this period the food for both birds was nailed to a second block placed exactly at leash-length from the block to which the female was tethered. In this way the female was conditioned to having the male eating from the same food at the same time that she was eating without being able either to take the food from him or to drive him away. Following this, and when observation showed no apparent hostility on the part of the female, she too was liberated in the room. Food was primarily fryer chicken heads or an occasional pigeon.

By March 15th there were some signs of sexual interest developing between the two birds, and some ceremonial bowing and clucking when both birds were on the nest ledge was observed. There was no behaviour that could be interpreted as being the domination of one bird by the other and both often ate together from the same pigeon or chicken head at the same time. Although no feeding of one bird by the other was observed at such times, it may easily have occurred.

Late in March, on the 21st for the male and the 23rd for the female, both birds entered a very early and very rapid moult that was complete by mid-July.

During May and June the female spent considerable time on the nest ledge in the brooding position, and on two observed occasions she spent the entire night there as well as the greater part of the ensuing day, but no eggs were produced. While none were expected from a bird of this age, there is one observation by Brooks, and two records from Alaska (Cade, T.J., Univ. Cal. Pub. Zool. 63:151-290, 1960) of immature-plumaged wild Peregrines incubating eggs.

The moult was sufficiently complete so that lure flying was resumed by the 22nd of June in the case of the male, and on the 27th of June by the female. By the 4th of July the falcons were under sufficient control that flights with both birds in the air together were again attempted. This time there was no aerial conflict and they were accordingly flown as a pair from the home building and over the home territory to lure, domestic pigeons, and wintering waterfowl until the winter solstice.

On the 22nd of December 1965 the free flights were discontinued, and the pair was strictly confined to the room in the building. The food supply was greatly increased and for about a week they ate nearly twice the amount of food that they had been receiving, then the food intake dropped quite sharply again. Otherwise there was no significant change in the behaviour of the pair for the first four weeks. Beginning early in February of 1966 there was a noticeable increase in the volume and variety of calls from the two birds. By the middle of the month they had become exceedingly noisy, the calls and chirpings of great variety being almost continuous throughout the daytime hours. This noise and apparent excitement built up until the 8th of March. On that date two hours of detailed observations were made. Both birds seemed to be very excited, and the male spent most of the time going through a repetitive ceremony or display. Standing on the nest ledge a little to one side of the nest hollow, a shallow depression the birds had already made in the turf covering the ledge, he would assume a horizontal position bowing three or four times with his eyes focussed on the female, then while making sharp, loud metallic chirps he would rotate his head so that the end of the beak, still pointing directly toward the female, described a small circle some two inches in diameter. This was varied at times by turning the head rather slowly to the upside-down position. Following this he would creep into the nest depression, there to turn around very slowly three or four turns, sometimes settling briefly to the brooding position. This was followed by a quick take-off and rapid flight around the room, past the female, and back to the nest ledge where the entire procedure would be repeated. Both birds were all the while very noisy.

From about mid - February the female had been spending much time, and some entire nights, in the brooding position in the nest-scrape. She spent the night of the 8th of March in the nest. The

next day, the 9th of March, both birds were absolutely silent. This silence was in such contrast to the great racket of the preceding day as to be indicative that egg-laying had probably begun. Two days later, on the 10th, by tossing a freshly killed pigeon into the room I was able to induce the female to leave the nest ledge for long enough for me to look briefly into the nest depression, which contained one egg. The female began her moult on the same day. By the 14th of March there were three eggs. Incubation was apparently begun with the second egg, for on the 12th of March and following, but not before, the eggs were continuously covered by one bird or the other.

During the first week of incubation great care was taken not to disturb the pair lest they abandon or perhaps even eat their eggs, but their unconcerned attitude encouraged observation. At the onset there was little sign from either bird of apprehension or of hostility to close observation. Only when the nest ledge was very closely approached would the female, if incubating, stand up and spread her wings in a threatening attitude. The female spent more time on the eggs than did the male. She always covered the eggs during the night. When food was delivered, it was usually taken by the male who would at once give a sharp, two-syllabled feeding call. The female would generally leave the eggs at once and fly across the room to accept the food from him. The male would then go directly to the nest and cover the eggs while the female ate and sometimes for a considerable period afterward while she bathed and preened or just spent some time perched. After a rather widely varying time interval she would fly to the nest ledge and there would then take place a little ceremony of bowing and clucking as the birds changed places. The female had favored corners into which she would tuck any uneaten portions of food after she had finished her meal. These hiding-places, if such they were, were not at all her secret however, for the male would go immediately to them and remove the food to the block or shelf perch to eat. The incubating female watched from the nest ledge with complete indifference. Occasionally when the male was incubating at the time food was presented, the female would accept the food directly. Usually the female ate first, but this was not an inflexible rule. If the female on the nest ignored his food call, the male would then eat first and cache any remaining food. He would then go to the nest ledge and offer to relieve the female. This offer was sometimes accepted and sometimes not. There appeared to be no fixed time that the male took over except that he incubated only during the day. While the male therefore spent much less time than the female on the nest, he nevertheless so spent some one-third to one-half of the daytime hours.

During the four-week period that the pair was permitted to incubate, neither of them showed any serious hostility or apprehension to close observation and, accordingly, a large series of 16 mm movies and 35 mm colour photographs was taken. The eggs were removed on April 16 and were later examined at South Dakota State University. No signs of embryonic development could be

found. Pesticide analyses of the three eggs produced in 1966 showed a rather low level of DDT, its metabolite DDE, and endrin (analyses conducted by Patuxent Wildlife Research Center of the Fish and Wildlife Service, U.S. Department of Interior).

The pair was left together from April 16th until June 11th on the chance that there might be another nesting attempt. During this time the pair again became quite noisy, and the female even spent the occasional night on the nest ledge in brooding position, but no more eggs were laid. The most marked change during this time was in the attitude of the female which became very aggressive to anyone attempting to enter the room. There was no apparent change in the behaviour of the male.

On the 3rd of June I left for the northern Queen Charlotte Islands on an expedition for Raptor Research Foundation to obtain a number of young falcons for future breeding experiments. I returned on the 9th of June with ten young Peregrines evenly divided as to sex, but varying in age from medium-sized downies only a little over a week old to well-feathered birds almost ready to fly.

Quite by coincidence all of these young birds were placed in the compartment of the building directly adjacent to the room holding the adult pair. The two old birds became extremely excited on hearing the calls of the young falcons. The reason for this excitement and what it meant was discovered the next day. On the 11th of June I went out to feed the young falcons and on entering the room noticed one of the largest of these standing with the beak pressed into a half-inch crack in the partition separating the two rooms. The young bird appeared to be taking food from one of the adults in the adjacent room. A quick visual check through the window from outside the building confirmed this. Two of the young falcons were therefore at once placed in the room with the two adults and watched closely to see what would happen. The young birds reacted instantly to the sight of the adults, running up to them with hunger screams and begging for food. The reaction of both adults was almost equally quick and definitive. Each immediately retrieved food remnants from their food-cache and each began feeding one of the young birds.

Following this, the care of all ten of the young Peregrines was entrusted to the two adults. Lights and cameras were again set up and a complete photographic record was made of the pair feeding, and the female defending the young. The female was far more agressive toward people than she had ever been before. The young were subsequently left with the adult pair for periods of time relative to their respective ages. They were removed singly or in pairs as they became fully fledged and capable of flight. The last pair was removed on the 9th of July. The female and some of the young are shown in the upper photograph on page 71.

The parallels between the 1966 Raptor Research experiment and the earlier nestings attempted by Waller's and Stevens' pairs are more striking than the differences. Nevertheless, there are some

Female Peregrine and adopted young, 1966

The author at nest ledge, 1967

contrasts. The female of this pair produced eggs two to four years earlier in life than did either of the other birds. Although the eggs of the first nesting attempt proved to be infertile, it may be significant that similar failures have been uniform with all initial attempts by any one pair, yet Waller's female is reported to have produced fertile eggs, if not young, in all subsequent nestings with each of the two males involved. The dates of egg production of the Raptor Research pair were strikingly similar to the dates set by Waller's female but quite different from those of Stevens' bird. The latter produced her eggs in April at about the same time as would be normal for wild falcons at the same latitude, while the other two were almost a month earlier than normal. One of the most consistent parallels with all of the pairs so far handled, as well as with unmated egg-producing females, is their willingness to adopt and care for young. Waller's pair adopted young Buzzards; Stevens' pair adopted young Merlins, and this before they had even produced eggs; while my pair adopted ten young of their own kind, but of widely varying ages and after a hiatus of some seven weeks following the enforced break-up of incubation. In each case both sexes took part in incubation. With the exception of Waller's female, which in the first instance did not join the male in the care of a young Buzzard, both sexes also took part in the feeding and care of any young in their vicinity, whether their own or not.

The 1967 Nesting Attempt. In late August of 1966 after the last of the adopted young Peregrines had been removed and after the adults had completed their moult an attempt was made to fly the two together during the late autumn months as had been done in 1965. This was not successful and the attempt at retraining was soon abandoned. While neither of the pair showed any tendency to leave the general area, there were some significant changes in behaviour which made both sexes very difficult to control but for rather different reasons. The male quickly took to flying at great heights and regularly refused to come down to the lure, being apparently interested only in live quarry. The female was even more annoying because she tended to ignore both lure and live quarry; much of the time she seemed entirely preoccupied with the defense of the entire area. To this end she would take perch, often well-hidden, in one of the many tall firs overlooking the saltmarsh. There she awaited the passing of any other large raptor such as a Red-tailed Hawk or an eagle, which she would at once attack. She made the area useless and dangerous as a training area for other hawks as long as she was free. Once released, she would refuse to be retaken for two or three days. Her recklessness in attacking other large and powerful raptors coupled with the opening of the autumn shooting season made her behaviour dangerous to her own life. The attempt at autumn flying of the pair was therefore discontinued after a two-week trial. Both birds were then returned to the confines of the building.

Beginning early in January of 1967 a small amount of wheat germ oil was used as a food additive but was discontinued when it became apparent that this substance was very distasteful to them.

By early February much of the pre-nesting behaviour that had been observed the previous year was again in evidence, but no very detailed observations were made this time.

Egg production dates were very similar to those of 1966, the first egg being laid between 7:00 and 7:30 AM on the morning of March 2nd. Egg laying then continued at regular 48-hour intervals for the second and third egg, the fourth being delayed an additional 24 hours. The set of four eggs was therefore complete on the 9th of March. Incubation had again begun with the second egg, as had been the case in 1966.

All four eggs were removed 24 hours later on the night of March 10th. At the time they were taken the female was covering only three of the eggs; the fourth lay some six inches from the others and was very cold. They were placed at once in an incubator for a two-week period but proved to be definitely infertile.

Inasmuch as the uniform flatness of the gravel-surfaced shelf had resulted in the falcon failing to cover all four eggs, the shelf was resurfaced with a two-inch thick turf that was sloped uniformly inward to a gravelled central depression. No other changes were made.

The recycling of the female was surprisingly rapid. The noise and activity that seem to be the prelude to ovulation were renewed within 48 hours of the removal of the eggs. Then, only two weeks later, on the morning of March 24th, the first of the second set of eggs appeared. In 1966 the moult of the female began with the laying of the first egg on March 5th; in 1967 the moult of the female began with the laying of the first egg of the second set of eggs on March 24th. No copulation was observed at any time, but on the morning that the first egg of the second set appeared the feathers at the base of the upper surface of the wings of the female were disarrayed.

Further egg-laying proceeded exactly as before with a 48-hour interval between the first and second, and second and third egg, and a sixty-hour interval between the third and fourth egg. Incubation began with the appearance of the second egg.

Inasmuch as detailed observations had been made of the behaviour of the pair during incubation in 1966, no close observations were made in 1967 until the end of the incubation period drew near. It was deemed advisable to permit full-term incubation because it was intended to provide the pair with young whether the eggs hatched or not.

During the final week of incubation there was a marked increase of aggressiveness on the part of the falcon. This made daily visual checks of the eggs rather easy, for all that was required to bring her off her eggs was the opening of the door leading into her room. On the 29th of April at 3:00 PM I checked the eggs this way and as the falcon left her eggs and walked with

spread wings and lowered head to the edge of the shelf one of the eggs began to rock violently from side to side, then split open and out rolled a young Peregrine. I left the building at once.

Lights and cameras were at once set up in the room adjacent as they had been in 1966. It seems curious that the opening of the door between the two rooms always aroused the female to threatening aggressive posturing or real attack, while the removal of the eighteen-inch high panels immediately above the door caused no hostility at all. Nor did the placing of cameras and the arranging of floodlights as long as these were placed in position by reaching into the room through the opening above the partition. The partition wall, therefore, appeared to be a very clear and sharply-defined boundary to her nesting territory in so far as humans were concerned. The author at the nest ledge and the pair with eggs are shown in the lower photograph on page 71 and the upper photograph on page 75, respectively.

Few photographs were taken during the afternoon and evening of April 29th, but some very interesting observations were made. While the eggs and the one nestling were covered almost continuously, both birds appeared to be very aware of the newly-hatched chick. I had thought it unlikely that the female would permit the male on the nest once the eggs had hatched, but this was not so. One of the most fascinating of the little incidents observed at this time was of the male coming to the nest ledge and slowly creeping in under the female until he forced her to stand and step carefully back, thus uncovering the squirming peeping baby. At this point both birds stood for some thirty seconds gazing with fascinated intensity at the little one. The female then moved another careful step backward to permit the male to slide in under her and cover the nestling and the remaining three eggs.

Earlier in the day, before the egg had hatched, a rather large dead pigeon had been given to the pair. This pigeon had been partially plucked and tucked into one of the storage crevices at ground level. During the observation period the male began working to get this pigeon up to the nest site. This in itself was interesting and new, for during incubation no food items had been taken to the nest ledge that I had observed. He spent some considerable time in plucking this pigeon before attempting to get it up to the nest ledge, and in the confined area he encountered no end of difficulty getting it up there. Whether his intent was to try to feed the chick or not could not be ascertained, for the female continued to cover the nest. At this point however, a major error in the construction of the nest ledge became apparent, for the pigeon tended to roll down the slope into the nest-hollow and he could not place it, and leave it, on the ledge beside the female. After struggling with it for a time he eventually removed it to a flat shelf ledge above and to the left of the nest ledge and left it there.

Pair with eggs, 1967

Newly hatched Peregrine, 1967

It appeared that something much smaller was needed. I went outside and caught a bantam chick three weeks old and tossed it in with the Peregrines.

Some observers of wild raptors are quite convinced that the presence of young in the nest somehow inhibits adult raptors from making kills in the near vicinity of the aerie site. This idea did not stand the test of experiment. The bantam chick was instantly attacked by the male and the female was aroused and went to the edge of the nest-ledge but the male had already caught the chick. He killed it at once, took it to the plucking block and spent the next hour plucking it of every vestige of feather or down. He ate the head and then stored the body without taking it up to the nest ledge.

After dark on the evening of April 29th the lights were turned off and the three eggs were taken from under the falcon for examination. Two eggs were pipped, one of which was silent and which appeared, even then, to be dead, and the other was very much alive. The third egg showed no sign of hatching. All three were placed back under the falcon, and the shed was vacated until the next day.

At 11:00 AM on April 30th observations were again begun with the idea of taking a full series of photographs, but when after a time the birds moved about and permitted a look into the nest there was no movement or sound from the nestling and within an hour or so it became obvious that it had died sometime during the night or early in the morning. The large dead pigeon was still, or again, on the same ledge where the male had placed it the day before. Before the dead chick was removed at about 3:00 PM, both adults had made what appeared to be attempts to rouse it, pushing at it a little with the rounded top of the beak and even gently picking up and lifting the head.

On the morning of the 1st of May a second egg appeared to have hatched as there was a half-shell in the nest, but no young was observed. Later in the day the falcon picked this shell up in her beak and removed it from the nest, at which time it was apparent that this was the egg containing the dead embryo which had somehow broken open in the nest. This half-shell containing the dead embryo was later retrieved and frozen.

The third egg was examined on the morning of May 2nd and found to contain a living chick, but the shell of the egg was somewhat crushed on one side. This egg hatched later in the day with some help and the hatching and subsequent drying of the tiny falcon was photographed (lower photograph on page 75). It was placed in an artificial brooder. The chick was still alive and peeping at midnight of the 2nd but was dead at 7:00 AM of the 3rd of May. Two days later the fourth egg was removed from the nest. It still showed no sign of hatching and on examination proved to be infertile.

If the first egg produced was the infertile egg and the egg with the dead embryo was the second, then the three eggs hatched, or were due to hatch, on a perfect thirty-two day interval from the date of laying. This is two to three days longer than the time interval (29 to 30 days) listed in the literature as being the normal incubation period for Peregrines. However, the death of the chicks so quickly after hatching suggests weakened chicks that may have been in the egg too long. The naturally hatched nestling could conceivably have been killed mechanically by having the large dead pigeon roll down onto it (and later removed) or by accident by one of the adults. Neither seems likely. In view of the obvious difficulty encountered in hatching by the other two chicks, it seems more probable that the cause of death was that of too much energy being expended in getting clear of the egg. Possibly there was an inadequacy in the diet of the adult falcon at the time of ovulation or possibly there was insufficient humidity in the nest. While the general humidity during incubation and at the time of hatching was never below sixty percent, and the turf surrounding the eggs was damp enough to support some growth of the grass in the turf, the gravelly sand in which the eggs lay was very dry. Moreover, and this may be important, the depth of material directly under the eggs was not more than two inches; there was an inch or so of gravel and sand, then a one-inch thickness of wood, below which was air. The eggs could have dried from below. There is a suggestion here that the artificial nest site should be constructed to take the form of a built-up ledge of some material such as turf or concrete, in constant contact with the ground, that will conduct moisture to the eggs from below, instead of a soil or gravel-covered shelf.

The possibility of the death of the chicks being due to pesticide poisoning seems unlikely, yet should not be disregarded. Analyses are to be made of the 1967 eggs and nestlings.

Conclusions

On the basis of the 1966 experiments the successful domestic reproduction of the Peregrines appeared likely. It would seem to be important to have pairs that have been taken as nestlings and raised to reproductive age in close association both with mankind and with one another. To date there are only three recorded instances of females taken as nestlings being provided with natural mates and given a physical situation under which reproduction could be attempted, and it is significant that reproduction was attempted in all three cases.

Stevens, who began his experiments with a seven-year old female that did not produce eggs until her ninth year, felt that the length of time required for the female to reach reproductive age probably constituted a major problem. However, the experiment with the Raptor Research pair proved that ovulation can occur as early as the third year and may indicate that the need of a preconditioning period of some duration in company with a male may have been the reason for the two-year delay in ovulation observed by Stevens.

There is an appearance of a low fertility in the experimental pairs. Of the nine recorded nestings by three females and four males, all four initial attempts were failures and in two of these the cause of the failure appeared to be infertility. Two second, and one third nesting, all by Waller's female, resulted in fertile eggs, yet Stevens' pair produced infertile eggs on the third nesting attempt. The fertility or otherwise of the eggs produced in the two previous attempts by his pair is not known. Obviously the sample is too low to be indicative of anything conclusive. Even in the cases where the eggs were apparently infertile, the reason is not clear, and it is not known whether the male failed to produce sperm or whether the failure was due simply to a lack of attempted or effective copulation. No attempts at copulation were observed with the Raptor Research pair, but the same was true of the successful nestings by Waller's pair. Observations of natural pairs, where copulations have been recorded, indicate that while fairly frequent prior to egg-laying, it is also very brief and could easily escape observation (Cade, T.J., Univ. Cal. Pub. Zool. 63:151-290, 1960). At the same time the lack of fertility of at least some initial nestings, and this may extend to birds in the natural environment, may be due to nothing more than apprehension or inexperience on the part of the male.

However, when the experimental data are examined comparatively, one fact appears at once significant. This is the advanced timing of egg-production in the captive females. Except for Stevens' bird, which laid eggs in April, all eggs were produced from two to six weeks earlier than the normal dates of egg production of wild Peregrines living at the same latitude. Even assuming that the males--excluding the wild-caught male used by Waller--were not actually biologically infertile there would appear to be a good chance that the females were nevertheless laying eggs some weeks in advance of any potential sexual capability on the part of the males. If this were so, then any means of delaying or extending the ovulation period of the female might result in fertility. Oologists have long been sure that Peregrines breeding in the mid-latitudes will regularly lay a second, and sometimes a third set of eggs if the first set is taken before incubation is very advanced. It was therefore decided that if eggs were produced in 1967 before the first week of April they would be removed as soon as the set was completed.

Waller's experiments, while twice productive, remained inconclusive in that the successful hatchings were relative to the use of an adult, wild-caught male. While he recorded one fertile egg as having been produced by his falcon when in company with the first male, the validity of this report had been questioned, especially when Stevens was unable to obtain fertile eggs from his pair in which both sexes had been taken as nestlings. There now appears to be no valid reason to doubt that Waller did, in fact, obtain fertility on the second attempted nesting of his original pair.

The failure of Stevens' pair to attain fertility is more difficult to explain, especially as his falcon was producing eggs in April when the male should, presumably, have been as sexually advanced as the female. There is a suggestion here, when taken in context with the uniform failure of initial attempts by all pairs so far recorded, that prolonged association with an ovulating female may be a great stimulus toward sexual activity on the part of all males, and perhaps a necessity to some.

The uniformity with which such a very small number of experimental pairs has attempted to reproduce is indicative that a very high percentage of eyas pairs will make similar attempts if given the opportunity, and there now appears to be no reason why a good many of them should not be successful. All experiments to date indicate that Peregrines are extremely devoted both to incubation of the eggs and to care of the young.

Finally, it would now appear certain that the spatial requirements of Peregrines, and, by inference, of the other large falcons, differ in no significant way from those of other raptorial birds and many of the mammalian carnivores, being conditioned much more by an abundant food supply than any other single factor. Even the apparent minimal half-mile that normally separates the closest aeries may be much more a reflection of the average distance required by the male Peregrine to overtake prey from a starting point close to the aerie site without interference from the male of an adjacent pair, than to any inherent hostility toward other adult Peregrines. At any rate it is now definite that close confinement is no barrier to normal reproductive activity of either sex, and may be a stimulus to the female (see discussion in the Appendix of this paper).

The tendency of Peregrines to nest relatively close together in areas of high availability of food would further indicate that themuch closer proximity of other pairs breeding in confinement should also have no negative effect on reproduction. Enderson's Prairie Falcon studies (Auk 81:332-352, 1964) indicate that even the exchanging of mates of mature birds might be possible and at times advantageous.

Future Plans and Suggestions

A long term objective of the Raptor Research Foundation is the acquisition and distribution of potential breeding stock and the working out of practical techniques by which such stock can be retained in good health and with a minimum risk of loss for the two or three year interval prior to reaching reproductive age.

Some of the experiments to date indicate certain advantages to a course of training during this pre-adult period. In the first place, the regular handling then involved accustoms the birds to intimate contact with humans and the birds become reasonably tame. Equally important is the high degree of trust and tolerance between the sexes which can be effected if, beginning at an early age, they

are flown to the lure together. By flying them only to the lure and always in the same area, the risk of loss can be minimized while at the same time they can be kept in vigorous condition and excellent health.

Some of the current experiments by Raptor Research cooperators on the other hand are oriented toward eliminating the problems of time and skill inherent in any such training program. This would then only necessitate keeping a pair of birds taken as nestlings confined together for the length of time necessary for them to reach reproductive age. Inasmuch as this is essentially the procedure that has resulted in reproduction by many species of raptors in zoological parks, there is some reason to believe that such pairs might reproduce just as effectively as those that have been given outdoor flying during their pre-adult years. To my knowledge nothing of this kind has ever been given a fair trial with Peregrines. What is well known to falconers is that many Peregrines, and nearly all Gyrfalcons, if tied to a block and given no exercise at all, are extremely susceptible to aspergillosis. The degree to which the not inconsiderable exercise of flying about in a small room might make them less susceptible is not known. However, some Peregrines have been kept, as lone birds under these conditions, and have lived for many years.

The accumulation of the specialized knowledge prerequisite to the husbandry of any long-lived, slow-maturing species can not be hurried. The final objective must always be successful reproduction by a minimum of two, preferably unrelated, pairs that have themselves been produced in the artificial environment. With Peregrines this can not possibly be attained before 1971. Nevertheless, there are at least three pairs of adult Peregrines of known origin and background that have been provided with facilities under which reproduction could have occurred in 1967. Two of these were new pairs, and one of these has produced eggs. In addition, similar facilities have been made available to at least one pair of Prairie Falcons and one pair of Goshawks. Of these, the Prairie Falcons have produced two sets of eggs, the first set infertile.

By 1968 two more pairs of Peregrines could be added from immature birds that are already on hand, while by 1969 Raptor Research cooperators alone could have seven pairs of reproductive age plus a number of younger replacement birds or potential breeders, while the total number of adult pairs should number close to twelve. These pairs are widely spaced across the continent, both in Canada and in the United States, so that any losses to accident or disease in any one place can not be disastrous to the entire project. Some experiments with female Gyrfalcons relative to egg production are possible by 1967, but with mated pairs not before 1970. By 1971 the first nestings by domestic-bred Peregrines are possible, and this is a current target date. By the mid-1970's the domestication of the Peregrine should be an accomplished fact and from then on the demands of falconers on the wild population should level off and consequently decline, as an increasing number

of domestic birds come to reproductive age and as a more detailed knowledge of the husbandry of the species is accumulated.

(Editors' Note. Another important objective of the Raptor Research Foundation Breeding Projects is to provide a source of experimental birds for further investigations in raptor biology. In addition, the Foundation is very interested in developing techniques of re-introduction into areas where populations have been lost.)

Appendix*

The exact set of conditions that leads to initial pair formation in free-living raptorial birds is extremely difficult to ascertain in the field and is impossible to duplicate in an experimental situation. Nevertheless, falconers working with a number of birds of both sexes do have opportunities to obtain an intimate insight into the nature of some of the pre-conditions to pair formation that are not available to most field naturalists. If my observations and experiments are at all meaningful, some of the conditioning experiences take place at a very early age.

First of all there is probably some kind of a visual influence on a nestling of the type of countryside in which the nest site is located as well as of the actual nest site itself. This information seems to be permanently retained throughout the life of the bird and tends to make it return on, or possibly before, reaching reproductive age, either to the vicinity of the home nest or to some place not far removed that closely resembles the home nest. This may well be the most important reason why eyas falcons will attempt to reproduce in an artificial situation while birds taken from the wild population later in life will not. Two other pre-conditioning experiences also take place quite early in the life of the wild birds. As soon as they fly well at all, the young take to intercepting the incoming, food-laden parent and, if there is more than one young in the brood, this behaviour quickly becomes highly competitive, the food being snatched from the feet of the adult while both birds are in flight. It is but a step from this pursuit of the adult to the pursuit and snatching of food from one another of the same brood. It is at this stage of development that the larger size of the females first becomes biologically important and from here on there then begins a series of experiences that recur often enough to be an important factor in the developmental patterns of both of the sexes. The larger females can consistently

* Editors' Note: The material in this Appendix is a discussion of sexual dimorphism, pair formation, territoriality, food availability, populations, and survival in Peregrines. It is included here rather than in the main text of the paper because of its length, its intrinsic value, and its theoretical value as a basis for some of Beebe's procedures.

overtake the males and snatch food from them when they are laden. At the same time, and this is very noticeable both in Peregrines and the large accipiters, the males develop speed and flying skill considerably more rapidly than do the females and it is the young male rather than the female that is most likely to make the initial intercept of a food-carrying adult. Later, because of this same flying skill, the males begin successful hunting in advance of the females but only to have many of their catches snatched from them. This piracy of the males by the females is very much a part of the early experiences of both sexes in every brood where both sexes occur. Moreover, it must be a relatively commonplace experience throughout the life of every male Peregrine. It seems to me that the cumulative effect of this piracy would be both to eliminate (by starvation) any inefficient males and to make surviving males extremely efficient hunters. Surviving males would also learn to accept this piracy as a recurring norm by the time that reproductive age is reached, and probably much sooner.

Applying this concept of pair formation to experiment, and working with pairs of first-year birds of about the same age, the males can be conditioned in two to three weeks' time to a degree of indifference such that they will come down to feed, in company with a female, on a kill or lure that has been taken from them in the air by that female. That this commonly happens with immature birds in the natural situation is doubtful. More likely, the male simply has his prey snatched from him and must seek another quarry for himself. Nevertheless the pirating of the males is normal, and in my opinion a rather rigid pre-condition to initial pair formation that the male be situated in an area where prey is so abundant and regularly available that he need not leave despite the continuous presence of the piratical female. It is probably only under these conditions and with this pre-sexual relationship established very slowly over a period of one or more years during which no eggs are laid that new pairs are formed.

The experimental data certainly imply that the female must be maintained in very high condition and do little hunting before ovulation can occur. The production of eggs by unmated females in the natural situation is unknown, yet the holding of aerie sites by apparently unmated females in the natural environment does occur, and this even in areas where Peregrines are abundant and unmated males should presumably be available. Such lone females are often assumed to be individuals that have lost their mates, but the very rapid replacement of male birds at active aerie sites where the original male has been shot or trapped is well-recorded. Where these lone females occur in vigorous populations, it is possible that they represent a type of aberrant individual that could easily occur in a predatory bird, being simply a falcon so fierce as to be a threat to the life of any male or, and perhaps this is essentially the same thing, a falcon that for some reason persistently continues to do her own hunting. Either way or in combination, the sedentary state would not be attained and such birds presumably would not lay eggs. Similarly, in years of low food supply the necessity of continued activity on the part of the

female would reduce or inhibit reproductive capacity even in normally highly productive pairs.

The concept that the large falcons always mate for life has been questioned in recent studies. Nevertheless there are good records of the same pair occupying certain aeries for many years in succession (Herbert, R.A. and Herbert, M.G.S., Auk 82:62-94, 1965). This situation may be more characteristic of relict or weakened populations than of dynamic and healthy populations. Certainly the rapid replacement of the males in experimental situations with Peregrines, and the frequent change of mates indicated by Enderson (Auk 81:332-352, 1964) in his study of Wyoming and Colorado Prairie Falcons would indicate that most females, once mated, will accept any male during the reproductive season. That intruding males in a territory occupied by a pair are driven off by the resident male, and not by the female, is also indicative of this.

In areas where abundant nesting sites and seasonally abundant food coincide, Peregrine populations tend to take the form of extensive "colonies." These are generally linear or peripheral and while based somewhat on local topography, the primary relationship is to the food supply, the pairs being from under half a mile to one or more miles apart along a stream, or around a lake or island. The population densities encountered in these circumstances can be very misleading if the observer interprets the density of population in the colony as extending evenly outward in all directions, or even as extending lineally indefinitely, relative to nesting sites only, as along a river or a sea coast. The large population of Peregrines breeding on the Queen Charlotte Islands takes the form of six well-defined colonies which are based on a similar number of breeding concentrations of Ancient Murrelets, Cassin's Auklets, and Petrels. An equally well-defined colony on the Scott Islands off the northwest tip of Vancouver Island is based on a great breeding concentration of Cassin's Auklet. A colony of at least four pairs with aeries on the cliffs overlooking Campbell Lake south of Inuvik in the Mackenzie Territory of the Canadian Arctic appeared to be based primarily on the utilization of Arctic Terns which used this valley as a flyway. The populations of the Thelon and Mackenzie Rivers show similar concentrations, that of the Thelon being concentrated almost entirely in a lineal distance of some 25 miles according to E. Kuyt, Canadian Wildlife Service Biologist. The population of the lower Mackenzie River takes the same form, with two widely separated concentrations of Peregrine population, and Cade (Univ. Cal. Pub. Zool. 63:151-290, 1960) records similar colony-like densities on the Colville.

Some of the vanished populations seem to have had much the same distributional patterns. When first studied by R. A. Herbert, the Hudson River aeries still numbered nine or ten occupied sites (Herbert, R.A. and Herbert, M.G.S., Auk 82:62-94, 1965). This population was, at the time of the study, based primarily on the use of domestic pigeons supplemented by Yellow-shafted Flickers and Blue Jays. Inasmuch as the domestic pigeon is not a native

bird, it would appear likely that the primitive population of Peregrines along this river was based on the recorded use of the river valley as a flyway by the vast primitive population of passenger pigeons, under which circumstances it may well have been much larger than when first recorded. Similarly, the now-vanished Peregrine population of the Okanagan Valley of northern Washington and southern British Columbia, when first studied by Brooks in 1903, also consisted of groups of closely-spaced pairs. His early records list five pairs at roughly half-mile intervals on the cliffs overlooking Vaseaux Lake. There are no data on food species supporting this population, but the Peregrines here declined and vanished by 1927, coincident with the rapid development of irrigated agriculture in the valley which in turn could have caused the disappearance or the abrupt decline of some previously abundant species that could not tolerate the rapid change of habitat on the valley floor.

At any rate the tendency to form peripheral or lineal colonies around a food-supply or overlooking a flyway is natural to Peregrines and appears to be characteristic of healthy populations. Such colonies are almost certainly composed of closely related individuals that represent successful attempts by the offspring of a successful pioneering pair to return to, and themselves reproduce, as closely as possible to their own point of origin. In this situation Peregrines quite possibly change nest sites and mates as well rather frequently, as is indicated by Enderson (Auk 81:337-352, 1964) in his study of the biologically similar Prairie Falcon. Isolated pairs, where they occur, may fall into three categories. They may be (1) newly-mated, and presumably young, pioneer pairs attempting to utilize a new, or temporarily abundant food supply or they may be (2) old, long-established pairs persistently attempting to reproduce in a traditional situation of former abundance that is no longer adequate. Sometimes, however, isolated pairs are (3) holders of some minute fragment of habitat that is perfectly adequate and suitable for one pair but for no more than one pair. Long-established aeries on isolated seabird rocks, in narrow mountain passes or on isolated cliffs overlooking timbered country are the best examples of this third category. Here the topography is always such that it provides more than just the aerie site, tending always, in some way, to concentrate otherwise widely-dispersed prey species in the vicinity of the aerie. Reproductive success at such sites may be consistently high but the ultimate survival of young may well be low. It is studies of such isolated pairs rather than studies of healthy populations that has given wide acceptance to the concept of the Peregrine as being an intolerant species with very large territorial requirements.

Whatever the physiographic situation, the absolute requirement to successful reproduction in the wild is simply that the male be provided with frequent or regular opportunities to catch, in the air, some kind of small to medium-sized bird or birds at no great distance from the aerie site. The more abundant and the closer to the aerie site these can be obtained, the less are the territorial requirements for any one pair. In all of the experimental nestings

the male spent a considerable period of his time relieving the female of incubation duties. The more time, therefore, that the male must spend in hunting the less of his time is available for incubation. The greater the distance that food is captured from the aerie site, the smaller must be the quarry captured, but the smaller the quarry, the more frequently it must be hunted. A clear energy limitation to territory size is obvious, and this is not all, for the greater the distance the male must carry food toward the aerie site the greater is his exposure to piracy from other raptors, especially eagles and the larger buteos--unless he is in, or over, the territory of another pair of Peregrines.

During incubation, there is some reduction in the amount of food required due mostly to the very much reduced activity on the part of the female. Probably the more active natural male supporting a female would consume somewhat more, but this would again depend on the near availability, or otherwise, of the food taken.

The tendency observed in all of the experimental pairs to store food may also be of considerable significance. The practice was common to both sexes and to birds of both wild-caught and domestic-raised individuals. Uneaten kills are also commonly found near the aeries of wild pairs, so the behaviour must be normal and inherent in the species. In cool climates this storage of food may be of great importance during incubation and also during the early life of the young. Temperatures in the high thirties and low forties (Fahrenheit) are cool enough to suppress the activity of the flesh-flies and to slow decay considerably. In cool maritime climates, dead birds stored in the shade at ground level do not deteriorate significantly for several days, while in the arctic, even in mid-summer the permafrost with its constant 32° temperature is but a few inches below the surface lichens. Here, any small birds tucked into a hole in the ground-cover would keep even longer. The ability of Peregrines breeding in cool climates to store food may be an important factor in the greater success of this species in the higher latitudes.

One of the most significant behaviour patterns common to all of the experimental pairs that have produced eggs was their dedication to incubation. With the Raptor Research pair the longest observed time that the eggs were left uncovered was three minutes. The suggested implication is that falcon embryos are easily damaged or killed by any chilling of the egg. Most of what is known about temperature sensitivity of avian embryos relates to studies made of waterfowl or of gallinaceous birds where only the female incubates, and in these groups the eggs are left to cool for rather long periods without harm to the development of the embryos. It is very certainly known, however, that the newly-hatched young of the raptorial birds are extremely temperature sensitive and easily damaged by becoming chilled. If the developing embryo is as sensitive to damage or death by chilling as this combination infers, then one of the most lethal factors to successful reproduction would be any disturbance of sufficient intensity to keep both adults off the nest for any considerable time. The time required to do permanent

damage would of course vary with temperature and humidity, but there is an implication here that any attempt at intimate study of wild Peregrines during the incubation period, especially photographic or scientific studies of the eggs, could be disastrous to reproduction. Further, unless the individual attempting such a study were fully aware of the consequences of his own interference during this period, some very erroneous conclusions could be drawn as to the real cause of the resulting reproductive failure.

As long as the young birds are in the nest and probably for a period of from two to four weeks thereafter, the concept of each pair and its offspring living within a fairly well-defined territory has some validity. However, if there is any meaning at all in the work so far done with experimental pairs, it is that adult falcons are incapable of discerning their own young as distinct from the young of other pairs, and conversely, that young falcons are equally incapable of discerning their own parents as different or distinctive from other adults. It also appears that for a limited time, any adult Peregrine will attend and feed any immature-plumaged Peregrine that approaches it with the appropriate food-begging ritual. The random feeding of begging young of their own, and even of other species, by adults of many kinds of passerine birds is well known and recorded, but this behaviour seems to be unobserved in relation to the raptorial birds. Yet all of the experimental data clearly indicate that this can and does happen. Implied in this situation is the concept that the young of any one year may be rather less dependent on their true parents than they appear to be. Implied also is that flying young could have a considerably better chance of survival in areas where Peregrines have been able to build up colonies than in areas where the breeding pairs are widely separated. In the latter case, any inability to locate one of the only two adults in a vast area could prove fatal. In the former case this would be of less consequence as long as the young bird stayed within the very much larger area occupied by the colony.