

## CAPTIVE BREEDING OF SOME RAPTORS\*

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The decline of certain raptor species due to shooting, loss of nest sites, disturbances during incubation, nest robbing, insecticides, and in part due to unknown causes, which have posed particular threats to the Peregrine (Mebs, 1966; Beebe, 1967), has recently stimulated attempts to save these birds from extirpation by captive breeding. This is already a successful recognized technique for some of the larger animals in zoos. If Peregrines can be bred successfully in captivity, we can look forward to possible reintroduction of these birds in at least some parts of their range from which they have been extirpated.

With this in mind various groups have been formed, among them Raptor Research Foundation, having a broad research and conservation program. Prestwich (1955), Marquart (1967) and Kramer (in preparation) have compiled lists of successful or partly successful breeding attempts. There may have been more of them, which have not been published. So I will make a brief report on my breeding attempts with various species of raptors and include reports from others who have written me, or told me about their work. My birds were held primarily for behavior studies; comprehensive reports are in progress.

### American Kestrel

Unfortunately, I have only two copies of Raptor Research News. So I am citing Vol. I, No. 4, p. 56 (report from B.P.I.E., No. 1): one unsuccessful breeding attempt 1966 by Olendorff as well as "some past experience with light manipulation" by Hunter. According to White (1967, Rapt. Res. News, Vol. 2, No. 1, p. 2) one pair laid a clutch of 5 eggs, and a second clutch of 4 after four weeks; one young hatched in an incubator but failed to survive. Marquart (pers. comm.) cites a publication in Rapt. Res. News in which 40 of 41 attempts with American Kestrels (*Falco sparverius*) had "positive results." Willoughby and Cade (1964) were also successful in getting fertile eggs from several pairs kept indoors. That they

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\*This paper has first been published in Der Falkner, Vol. 18, 1968, pp. 28-33; a few parts, such as description of the species and acknowledgements, are left out here. I wish to thank Dr. Frances Hamerstrom for the translation.

offered new mates for each season, as well as the type of nest boxes used, may be one of the causes why they nearly always failed to rear any young.

Thanks to the friendly efforts of Drs. F. and F. Hamerstrom we obtained five migrant Kestrels from Wisconsin (2 young males, 2 young females and an adult male) which we took to Freiburg, Germany, with us.

After a short period of adjustment in a room at the Zoological Institute, I put the birds in a 2.5 x 5 x 2.8 meter pen in a brushy part of the Institute garden. The pen was divided by a partition into two halves of 2.5 x 2.5 meters, each of which was occupied by one pair. Those birds were put together as prospective mates which in the past had been seen sitting near each other more often than with one of the other three. Nevertheless, one male remained so shy, that when the other was already in lively display in the spring of 1961, I gave him away to the Frankfurt Zoo, and brought his intended mate into my office where the adult male (tame from the start and as long as he shared my room alone) had spent the winter flying free. Both pairs bred the first season, but unsuccessfully. Then I moved the office pair into the outdoor pen too and since 1962 and 1963 respectively (Table 1) both pairs have hatched young every year and, except when I removed some of the young prematurely, they raised their own young well. In recent years the doors in the partition were left open so that the birds could fly the full length of the pen, but each pair perches only in its own division. Breeding and fledging success of these two pairs is given for eight years in Table 1.

The much calmer female "Fran" in almost every year had more young than "Elva" who normally starts to lay later and perhaps as a result less often produces a second clutch. Second clutches were most often produced either after the eggs had become addled or after I had taken away the nestlings to hand rear them. In at least one instance the pair "Alan/Fran" began a second brood after they had successfully fledged the first one. In the southern part of the range second broods are said to occur normally in the wild. The normal clutch is 4-5. I may have failed to detect eggs lost during laying or incubation especially in the case of the touchier pair "Hammi/Elva," as I disturbed them as little as possible. Very seldom one of the eggs was infertile. Losses were almost entirely due to death of embryos, especially resulting from disturbances during the hatch or shortly before. There were hardly any losses during rearing: of 64 hatched, 3 died and 61 grew up healthy. The losses pertaining to eggs are greater in second clutches when the readiness to incubate is less.

Table 1

## Reproductive success of American Kestrels, first generation

Breeding Pair		First Clutch			Second Clutch		
		Laying started	No. of eggs	No. fledged	Laying started	No. of eggs	No. fledged
Alan and Fran	Apr. 19 '61		5	0			
	12 '62		5	5			
	4 '63		5	5		3	0
	7 '64		5	5	June 13 '64	5	2
	9 '65		5	4	20 '65	5	4
	4 '66		5	3	8 '66	5	4
	Mar. 29 '67		5	5	1 '67	5	1
	Apr. 8/9 '68		5	5			
Hammi and Elva	May 9 '61		5	0			
	Apr. 24 '62		2	0			
	16 '63		3	3			
	19 '64		5	5			
	15 '65		5	3			
	12 '66		5	4	June 16 '66	3	0
	15 '67		5	0	3 '67	5	2
	16/17 '68		5	1			
Total			75	48		31	13

Table 2

## Reproductive success of American Kestrels, second generation

Breeding Pair		First Clutch			Second Clutch		
		Laying started	No. of eggs	No. fledged	Laying started	No. of eggs	No. fledged
VR	♀ SB	Apr. 9 '63	4	0	June 6 '63	4	0
WR	♀ BB	9 '63	5	0	May 21 '63	4	0
		16 '64	5	0	25 '64	5	0
WR	♀ LT	May 9 '65	4	0			
WR	♀ RR	7 '66	5	1			
		Apr. 24 '67	3	2			
		1/2 '68	5	1	June 20/21 '68	4	2
Total			31	4		17	2

VR = Much-red

BB = Broad-banded

WR = Little-red

LT = Left-turquoise

SB = Small-banded

RR = Red-ring

Experiments with second generation captive bred Kestrels

Alan and Fran in 1962 had two sons "Much-red" and "Little-red." I took them from the nest at 10 to 12 days of age to hand rear. Next year they bred with their sisters "Small-banded" and "Broad-banded" from the same clutch, but which had not been taken from their parents until about 4 weeks old, when they left the nest box by themselves. These two pairs bred in my office which was divided into three parts with a fishnet partition. Both of them had two clutches in 1963, as well as the pair Little-red/Broad-banded in 1964, each first clutch being infertile, the second fertile. Male Much-red became so aggressive during the breeding season that I gave him away in the autumn. Male Little-red has remained unchangingly tame; after the breeding season 1966 I put him in a roomy pen with his third spouse--the first two became insufferably aggressive. As Table 2 shows fledging success was relatively tiny, but these failures showed me how by luck I had done some things right with the older pairs. These too raised no young in their first season, Hammi/Elva not even in their second season. In 1963, first season of the second generation, all four partners were yearling first time breeders. They laid 17 eggs, but hatched no young. In both 1965 and 1966 the females were again yearling first time breeders mated to Much-red. The first young he and his third spouse "Red-ring" finally hatched in 1966 was handraised; the following ones were reared by their parents.

Instead of the weatherproof compressed wood-and-concrete boxes with cup shaped bottoms which I use outdoors, simple boxes made of planed boards seemed to give sufficient shelter for those breeding indoors. But the birds shoved aside any litter I gave them until the eggs lay on the bare floor and rolled away when the females tried to sit on them. So they were always restless, got up very often to tidy up, spent too little time incubating without interruption, and the embryos died. Besides, as mentioned above, in 1963 and 1964 only the second clutches of the pairs breeding indoors were fertile. Those first clutches, which were forceably delayed about four weeks by putting the pair together too late (Little-red/Left-turquoise 1965 and Little-red/Red-ring 1966, Table 2; Hammi/Elva 1961, Table 1) were fertile too as well as all the American Kestrel clutches in the outdoor pens. Copulation occurred here just as often but was successful indoors a few weeks later than outdoors: the males needed more light, which was confirmed by giving additional light indoors (instead of waiting for longer days in May, about four weeks after the normal onset of laying), and also proved to be the case with captive European Kestrels living in pens (see p. 9). Also, the later onset of breeding by Hammi/Elva may be due to the fact that their part of the pen is shadier than that of Allen/Fran. The second generation hatched nine young of which six fledged.

I am still in touch with owners of some of my Kestrels and have learned that a few of them have bred in other places. The passage tercel and a young female I gave to the Frankfurt Zoo raised two young from four eggs in 1966, three young in 1967, and after the death of the old female one of these young had three apparently infertile eggs in 1968. In Seewiesen, H. Albrecht's yearling pair had an infertile clutch in 1965, a fertile clutch in 1966 and two fertile clutches in 1967. The female died on the second clutch and in no instance did any young hatch. Female Broad-banded (Table 2) mated in 1965 with a male two years younger laid, at Mr. Herrn's, 5 infertile eggs. Of two pairs reared in 1966 the one, at Mr. Peithmann's, produced 5 fertile eggs in 1967 of which one young fledged (in 1968 they failed to breed because of disturbances during courtship); the other, at Mr. Fessner's, brought off 5 young in 1967; on May 26, 1968, this pair was incubating.

### European Kestrel

Detmers (1905) reported that the European Kestrel, *Falco tinnunculus*, "has bred in captivity several times . . . So I read in the paper . . . that a pair of kestrels, which have already bred in a cage, are for sale for 50 Marks, the cage included." Hoffmann (1906) writes: In a 2 meter high and "respectively wide" pen, which they shared with several owls, a three year old male mated with a two year old female, both of which were hand reared. In mid-May she laid two eggs, which she abandoned when she was moved to another cage. In the next year, starting on April 26, she laid four eggs (laying dates suggest to me that a fifth was lost), and hatched and raised three young; the fourth egg was "probably unfertilized." Prestwich (1955) mentions a brood in 1867, and another in 1849 with 5 young which were killed by the female a day or two after hatching (or did she not feed them properly and just eat them after they had died of starvation?), and a third pair which raised several young within two seasons, described in 1896. He further quotes a general note from 1899, which presumably refers to the abovementioned three cases. Marquart (1967) mentions one clutch in Vincennes in 1935, one in Berlin in 1960, two in Prague in 1961 and 1964, one in Amsterdam in 1964, which were partly successful, and two in 1965 and 1966 in Tel Aviv, where even hybrids between European Kestrel and the Lesser Kestrel, *Falco naumanni*, were raised. His (pers. comm.) own European Kestrels, a yearling male and a three year old female, laid four eggs between May 23-31 in 1968 (the fifth could have been lost), hatched 3 young of which two starved to death and the third grew up normally. Herren (pers. comm.) kept a female for seven years, which could not fly. She displayed to her keeper, but would not tolerate an older tercel. For several years she laid

3-6 eggs which she incubated and twice, when fertile eggs were slipped under her, she raised young: once one and once three.\*

On July 12, 1959, a 22-25 day old European Kestrel was brought to me. Her previous background remains among the mysteries, but she appeared to have been kept in captivity for some time, for unlike birds freshly taken from the nest at the same age "Kauz" seemed manned. In the spring of 1960 she started to display to me, selected a desk drawer for her nesting place and laid six eggs between April 28 and May 18. She incubated off and on, but never assiduously; however, she settled down to care for two nestlings, of which one was slipped under her while still in the egg, three days after her last egg was laid; the second was added a few hours after the hatch of the first one. We raised them together. Later she never again adopted young--at least not older young. By contrast a three year old eyas male "Nicki" without brood experience was at first afraid of four 16-19 day old nestlings given him, but adopted them within a few hours and henceforth fed them with such enthusiasm that he even stole sausage from the table.

Just as Kauz's two adopted young were fledged we went away for three months. Thereafter the good old companionship was never fully re-established. True, in the next two springs she displayed to me, but rather too violently and with intermittent enraged attacks. In 1961 she laid eight eggs (Apr. 3 - May 25) on a screened balcony and in 1962, in my office, she laid eight again (May 7 - June 4), but one was in a nook far from the nest and she hardly incubated at all. I released her in September 1962.

From 1962 to 1966 I put a pair each in 2 or 3 old song bird cages 2 x 2 x 2 meters in size or in a 2.50 x 5 x 2.50 meter flight cage. Each spring they all got more or less into the breeding mood, but never copulated--not even when the females invited. Only male Nicki and female "Sempacherin" incubated an infertile clutch of 5 eggs in 1964 (laying started Apr. 21), until I took the eggs away after four weeks. In 1966 she incubated six infertile eggs (laying started Apr. 28) with male "Kölner." On the 5th of May I heard them copulating once. These lived in the sunniest pen.

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\*Meanwhile, Kramer (pers. comm.) found out eight other cases of captive European Kestrels which produced eggs, maybe even young and one breeding attempt of Lesser Kestrels in Norfolk Wildlife Park, where some young hatched, but died. Röder (pers. comm.) in 1968 obtained young from a pair of European Kestrels treated with hormones. They had no downs at all, but developed a normal plumage afterwards.

### Experiments with increased light

I believed to have dispensed with other possible causes of failure--especially with excessive attachment to the keeper. Again and again the behavior of the birds gave one the impression that they barely missed full reproductive thresholds. Finally, the behavior of the European Kestrels in different pens more or less exposed to the sun and also the experiences with the American Kestrels breeding indoors suggested insufficient light. This seemed amazing as the American Kestrels bred successfully in nearby outdoor pens and by contrast the European Kestrels came from the very region in which we lived; in other words the captives shared the day-night rhythm of those in the wild.

The birds in the wild, however, especially the males, spend many hours soaring during the display season--often above the clouds and are far more in contact with the sun's rays than in the pens which are often shaded by clouds, houses or trees. The females tend to spend much of their time sitting by the selected nest site.

The urge to fly of the captive males during this period is greatly intensified and their restlessness a trial to the observer. In normal day length, there appears to be a threshold of light necessary for attaining full reproductive capacity--especially of the males. This threshold seems to vary from species to species.

In the winter of 1966-67, I fastened a flood light to the wire top of the three European Kestrel pens and beneath it, at an appropriate distance, I put a branch-perch, invitingly placed. Except on overcast days, it was scarcely lighter in the pens than elsewhere in the daytime. So I kept the light on in the evenings. Thus I "lengthened the day" to equalize the amount of light received. In 1967, starting gradually in mid-January, I increased day length from about 10 to nearly 17 hours in mid-April. In 1968 I did similarly but increased it faster from early March till mid-April.

The first season I kept the flood light burning in the evenings until June 2, when the point was reached at which it was turned off at natural twilight. In the following year I stopped artificial lighting on May 1. The birds often sat directly in the light and dozed and preened and seemed content. The restlessness and the desire to fly was markedly less than in earlier years. Sudden shutting off of the light didn't seem to frighten them, as a good many lights were still on in nearby campus buildings. Some went to roost before it was dark.

Table 3 shows the results of artificial lighting on two pairs. The male Kölner was a full adult, female Sempacherin was a yearling

when they had been taken up with injured wings, he in 1965, she in 1960. Both these wild caught adults seemed to be very content with each other as soon as they were put together in May 1965, in contrast to most handreared birds. The flightless female lost an egg on the way to the nest with each first clutch, that is to say that twice she laid one more than the five she brooded and which are mentioned in the table.

Table 3

Breeding results of two European Kestrel pairs

Breeding Pair	First Clutch				Second Clutch				Fledged
	Laying started	Eggs	+	-	Laying started	Eggs	+	-	
K&S	Apr. 19 '67	5	3	2	May 18/19 '67	5	5		5
	16/17 '68	5	5		June 8/9 '68	5	(2)	3	
GR &GE	25/26 '67	5	4	1	May 20/21 '67	5	4	1	3
	18/19 '68	6	6						6
Total		21	18	3		15	11	4	14

Legend: + = fertile  
 - = infertile  
 K = Kölner  
 S = Sempacherin  
 GR = Green  
 GE = "Of the prison"

I had hand-reared male "Green" with five sibs from the egg. Though this is only one case, he proves that Kestrels raised in isolation from adult members of their own species can do without this experience and select mates and breed successfully. Female "of the prison" was received in 1965 as a wild orphan barely three weeks old.

In 1967, I took the eggs from both pairs after 10 to 14 days of incubation to open them. They laid and raised second clutches. In 1968 the first clutch of Kölner/Sempacherin died shortly before hatching. Presumably the deaths were attributable to cats, which one can't keep out of the garden. Of the second clutch two eggs may have been fertilized and died early, or they may have all been infertile. It is not clear whether or not this failure was due to reducing the lighting sooner, freak weather (very cold May after a warm April) or because it was then already rather late in the



season (laying started June 8-9). Green and female "Of the prison" kept their children until June 4, 1968; it was too late to start a second clutch thereafter.

Of 27 undoubtedly fertilized eggs of two pairs within two years 7 were killed by me by opening the eggs, 5 died at hatching time, 15 hatched, of which one was killed inadvertently by me and 14 grew up healthy.

The third pair, a three year old male and a two year old female, were also in full breeding condition in 1967, but, as in the preceding year, they were unable to get together--there was constant strife and beatings occurred. The male escaped in winter. In May 1968, having shared the pen with a subdued fully intimidated male, she laid four eggs, but failed to incubate.

### Peregrine

Waller (1962) has described his Peregrine (*Falco peregrinus*) breeding attempts comprehensively. One five year old falcon had a first clutch of 3 eggs and another of three eggs the following year of which at least one was fertile. Presumably, this happened in 1939 and 1940. In 1941, with another tercel, she had a third, but infertile clutch. In 1942, this pair had four eggs: one broke, one died at hatch time and two hatched. Of the two nestlings one probably died of starvation on the fifteenth day and the other fledged. In 1943, they again raised one young from a clutch of three eggs, one of which was infertile, and one failed to hatch.

Another female (Waller, pers. comm.), now in her eighth year, living with a strongly displaying Lanner (*Falco biarmicus*) tercel laid three infertile eggs in 1966 and 1967 respectively which she incubated steadily. In 1968, sharing the pen with a flightless Peregrine male, she had an infertile clutch of 5 eggs and failed to incubate properly. The male Lanner, now ten years old, tried in vain to copulate with a several year old Lanner falcon. In 1967, this falcon laid one, and in 1968 three infertile eggs.

Stevens (fide Beebe 1967) in 1959 placed a two year old Peregrine tercel with a seven year old Peregrine falcon. She laid three eggs in 1961 and 1962 and two in 1963, all of which she incubated. The first two clutches were disturbed and the third was infertile.

Beebe (1967) has comprehensively documented and discussed his early breeding attempts and excellent observations. His Canadian Peregrines, both 1963 birds, first started laying in a well illuminated room on March 8-9, 1966. On April 16, the three eggs were taken from them. They were infertile and there was no second clutch. On June 11 they adopted ten young newly taken from the

nest and raised them all well. The young varied in age between just over a week to almost fledged. In 1967 the first egg was laid on March 2 and was followed by two more at 48 hour intervals. The fourth was laid 72 hours later. They were artificially incubated and proved to be infertile.

The nesting ledge, which had been a smooth board covered with gravel on which the falcon could not settle down well on the eggs (compare with *F. sparverius*, p. 6), was converted to a depression. On March 24 she laid the first egg in it, the second and the third again appeared after 48 hours and the fourth after 60 hours. Copulation, as in Waller's birds, was not noted; only once was the usually smooth plumage of the falcon ruffled. On April 29 and March 2, two young hatched which died the following day. The third died at hatching time. The first laid egg was infertile. This account makes one hope that this year they have fledged young.

Fessner's (pers. comm.) Peregrines laid clutches of four eggs: in 1965, March 3-12; 1966, March 5-13 and, after this was removed on March 27, April 11-17. After this the three year old tercel died. With a new mate the falcon laid two clutches of four eggs in 1967. In 1968 she had four eggs by March 31. All of them were infertile.

Röder (pers. comm.) treated his tercel with hormones. He saw copulations up to 14 days before laying started. After artificial incubation one young hatched on April 28 and throve hand-reared by him, though its toes were crippled, presumably as a consequence of hormone treatment of the parents (compare with downless young Kestrels, p. 8). The other eggs were infertile.

In the summer of 1965, Mr. Martin (pers. comm.) came into possession of a Peregrine pair, which was said to have bred successfully in the hands of its former owner. In the spring of 1966 he arranged a roomy lattice pen with a shelter hut within. She laid 4 eggs on the sandy floor of the hut (March 4-12). By April 9 three eggs had been broken, and the fourth was found to be infertile--probably like the others. In 1967, from February on, a 100 watt bulb burned late into the evening beneath a low protective roof. Then the birds sat under it from time to time, but hardly ever during the day. Both the first (4 eggs, Febr. 28 - March 6) which was removed after ten days and the second clutch (3 eggs, March 26 - Apr. 1) were infertile. But the male displayed with much greater intensity than earlier, and shortly after the second clutch was completed, Martin saw copulations twice. The rather high strung male met his end a few weeks later. The female had always been remarkably calm and incubated dependably.

In late January 1968 this female was moved to the Forestry Station in Wittental where she was put in one half of a 4.15 x 6.20 meter pen of arched roof construction. A full adult tercel

of Mr. Biehler's inhabited the other half, which was illuminated from Febr. 7 on by a flood light with a 1000 watt bulb, placed 3.50 meters high. The light was turned on in such a way as to increase the day length from 10 to 15 hours, one hour weekly, to March 19, and another hour to April 12. It was no longer lighted after April 28. The male often perched on a high lattice right under the light, but when the partition door was opened a few days after the onset of artificial lighting, the female usurped this perch for the most part. The male sat nearby and was not able to enjoy it freely until she started to lay on March 11-12. She nested in a roofed packing crate set up on legs, filled 3-4 centimeters high with sand and gravel.

When natural twilight came, he tended to go to the darker recess where his night roost was. The birds got along well together from the start. The male displayed more vigorously than the first one. Chief forester Gauss thought he saw a copulation on March 12, but his view was partially screened by a wall of rushes. The three eggs laid by March 17-18 and incubated until April 8 were infertile. There was no second clutch.

#### Rufous-thighed Falconet

In past years the Rufous-thighed Falconet (*Microhierax caerulescens*) has been brought in from Thailand repeatedly. They are, one might say, passionate hole dwellers and differ markedly in behavior from the species already discussed. Hoppe (1967/68) describes 2 clutches of 6 and 3 eggs respectively, of which 3 were fertile but died early. In 1968 a female laid 7 eggs (May 12-25) of which five were fertile. On June 24 one hatched, but died two days later. Dr. Faust (pers. comm.), reporting from the Frankfurt Zoo, tells of a clutch of three infertile eggs and one over-sized egg which had to be removed from the female forceably in 1968. K. A. Muller (Rapt. Res. News, Vol. 1, No. 4, p. 56) of the Zoological Park in Washington reports of two infertile eggs (in 1967?).

In 1966, Prof. O. Koenig kindly gave me three Falconets which he had already had for two years. In 1967, after many copulations had taken place, on May 13 I found a broken egg which she had dropped. In 1968 they incubated steadily for four weeks on a clutch of six laid since April 23-24. Of these 5 were infertile, and the other died early.

#### Accipiters

Breeding attempts with the European Goshawk (*Accipiter gentilis*) were made by Waller (1962), Marquart (pers. comm.), Peithmann (pers. comm.) and Fessner (pers. comm.). Prestwich (1955) writes of an unmated hen, which having laid four eggs,

raised two young which were slipped under her; and also of a pair in Stockholm, which a few years before 1953 brooded three young (but apparently did not raise them).

Marquart (1967) questions Prestwich's statement about the Sparrow Hawk (*Accipiter nisus*), "this species has bred in confinement" and suspects that they were confused with Kestrels. But Mohr (1960) kept a hand-reared Sparrow Hawk hen, which displayed to him and laid four eggs, which she incubated steadily for eight weeks, after which he took them away from her.

With the help of Mr. Badshah, in July 1966, I got two young Shikras (*Accipiter badius*) from Madras, unfortunately two females. In 1967 the hen "Cleopatra" invited the somewhat smaller hen "Antonia" to mate and tolerated her on the artificial nest. She laid three eggs (May 1-6), which they took turns at incubating, till I took them away after four weeks. They spent the winter with two Red-headed Falcons (*Falco chiquera*) with which Antonia held her own better than Cleopatra. Antonia kept this ascendancy when I separated them from the Red-headed Falcons in spring 1968. To her only belonged the nest and Cleopatra was driven vehemently from any available space. Antonia laid three eggs which she incubated for a few days, but she abandoned them as soon as she was left alone, for I had to remove the terrified Cleopatra.

### Discussion

In the discussion I shall limit myself to points of importance for raptor breeding. Compared to owls, which are less subject to disturbance because of their predominantly nocturnal way of life, and for which a shady niche in a wall or an attic may suffice, diurnal raptors, especially the falcons, have seldom been raised. Among these the Kestrels and their close relatives are said to be relatively easy to breed. This difference appears to me to be less a difference in species than a difference in the usual ways to keep them: the larger falcons are almost entirely kept by falconers; one hardly sees them even in a zoo. This means that, except when up for molt, they are perched, tethered singly, and a strong personal bond between bird and owner is highly desirable for hunting together. "Nothing-but-ornithologists and pet keepers" (Waller 1962, p. 285) take on the smaller species, which are cheaper to get and to care for--in fact are often pressed upon people as foundlings, and besides these are livelier in captivity than the big ones, which unfold their full beauty in flight. The pet keepers place their charges in some sort of a room where they can fly free, and under favorable circumstances into a well arranged flying pen. The putting together of a pair brings opportunity near. If they get along, not too tame and not too scary, the location favorable, the spring bright and sunny, then they've just about got to breed. Thus most of the past inadvertent

successes are attributable to such circumstances. All these requirements, however, seldom are fulfilled spontaneously; one must be able to recognize them in order to meet them deliberately. Also experience with one species does not necessarily carry over into another.

Good, and preferably varied, food is of prime importance. At first I fed primarily horse meat: Tean muscle, heart, and in lesser amounts orts (insides of all types), as well as a mouse two or three times a week, and as opportunity offered, greenfinches and sparrows. Later I fed mice and day-old chicks exclusively, supplementing the Peregrine diet with pigeons, and the diet of the smaller raptors with mealworms, migratory locusts and crickets. When feeding straight meat one should roll the pieces in vitaminized calcium powder and especially during the laying period a dish of crumbled cuttlebone should be placed into the pen. They do not like fluid vitamin preparations, particularly if these have an odor of fruit nor, according to Beebe, wheat germ oil; they tear the meat into small pieces and toss them away with all signs of distaste. The vitamin compound A-D<sub>3</sub>-E aquosum put out by Hydro-Chemie, München-Allach, does not trouble them when injected into freshly killed food. Supplements to drinking water are not to be recommended.

The flight pen can be indoors, outside, or a combination of both. It must be light and offer protection against rain, wind and the midday sun; it should offer a variety of perches, as branches with the bark on, unplanned boards and rocks. There should be dry dusting sand available, which is eagerly used during the molt, and water for bathing should be supplied. For the most part falcons only drink when they are about to bathe, but the falcons during laying and for example the falconets with their high insect diet, must often drink without bathing. It is wrong to deprive them of the bath water as Hoffmann did, because the falcons sometimes return straight to the nest and thus moisten the eggs. In wet weather they rain bathe and drink rain.

Wire pens for raptors are generally disliked as they batter their plumage and soft parts on the wire. Nevertheless I use such pens and I find that most individuals--sooner or later--learn to spare themselves. Vertically strung wires are far better, but much more expensive. For the larger falcons one may use laths, iron rods, etc. Marquart (pers. comm.) recommends plantings in the pens, which I do not consider necessary for falcons. As the future nest site already plans an important part in display, this must be supplied early, preferably in winter: according to species compressed wood cavities, boxes protected from dampness, a dry place on the ground, or a shallow basket. A pre-fabricated depression seems desirable for all species, and essential for American Kestrels. The best litter, both for American and European

Kestrels, has been a mixture of commercial bird sand and saw dust; for Peregrines coarser, up to gravelly sand. The Falconets got along well with short wood shavings and also carried leaves, strips of paper and such things into the nest box.

In American Kestrels both sexes attain breeding condition in the first year; in European Kestrels, the male normally not until he has molted into adult plumage in the second year, and the larger falcons still later; however, according to pictures taken in the wild European Kestrels (see also p. 8, Marquart 1968) and Goshawks and according to Cade (quoted by Beebe 1967) even Peregrines now and then attain breeding condition when still in the immature plumage. In general, birds breeding for the first time have higher losses than older ones.

Whenever one has several birds available, one should try to leave mate selection to them, and not separate those which get along well together, or have bred together. Leave or put them together again the next season, if possible in the same place.

If raptors have a chance to become acquainted in connected pens, or the intended breeding chamber is temporarily partitioned, one can soon see whether or not they want to be together, and at the same time one may prevent one of them from becoming totally intimidated or even killed. The falcon, being larger and stronger than the male, should always be placed with a tercel already well adapted to his quarters--never the other way round. I also recommend caution whenever the birds are moved into strange quarters, for even strong pair bonds can thus be destroyed, at least temporarily. If they are flown, it can only benefit their health.

I have not yet been able to decide to what degree, if at all, imprinting, in the strict sense, occurs in falcons. It is well known to anyone who has hand-reared birds of various ages that the nestlings pass through a critical phase at about 10-14 days of age: young nestlings are all equally tame, then they turn very shy and defensive, but they still come around. I have already pointed out that even birds handreared from eggs and very tame birds which display to their keeper every year can breed successfully (see p. 6 and p. 10). However, a strong personal relationship with the keeper can cause disturbances, so one retreats as much as is feasible until the pair bond between the proposed breeders has been well established.

The influence of light and annual day length changes on the breeding cycle of birds has been documented in many experiments. Falcons, however, seem to have a greater need for light than such birds as members of the chicken family, ducks or songbirds which fits to the knowledge of their normal way of life (see p. 9). The females often lay eggs even if they have a substitute mate, but

often the intervals between one egg and the next are too long and irregular, sometimes they do not incubate steadily and sometimes not at all. Such failures never happened with the birds paired normally with members of their own species. When the male feeds the female and mounts her one can have a fair degree of assurance, but not certainty, that the eggs will be fertile (see p. 6). In the wild it is not uncommon for one egg, probably the first, to be infertile.

Copulation occurs to strengthen the pair bond long before the male is in condition to inseminate the female and, with American Kestrels, well into incubation. During the course of display the rhythms of both partners become synchronized, and this seems to be the greatest problem under captive conditions. The females are ready earlier. In addition the displaying male is always present in the pen, whereas in the wild the female is often alone till the male returns with a kill or from soaring. She starts to lay before he is even ready to copulate (see pp. 8, 12 & 13).

I have not tried using hormones. The other method, using light to stimulate the gonads has proved satisfactory even though the duration and intensities of the light were arbitrary. It will take much more experience to recommend sure solutions, and, as formerly in isolated cases, local and individual conditions and facilities will also be decisive. Marquart (pers. comm.) too stresses "une intense luminosité," and similar attempts seem to be in progress in the United States (see p. 3).

In the wild too, some males take their turn at incubating; how often and how long seems to depend upon the species as well as on individual differences. In captivity where there is more idleness, if a male spends more time on the eggs than is good for the development of the embryos one sometimes has to take measures, such as placing two breeding pens side by side to divert the males to defense of the territorial boundary.

It is not easy to candle colored, spotted eggs; when in doubt one can wait, try artificial incubation or decide to open the eggs. If the first clutch was laid on time, there is a good likelihood that after 4 weeks of incubation and even later a second clutch will be laid--usually about two weeks after the loss of the eggs or young. Handrearing from the egg is possible, but it takes a lot of circumspection. It is doubtless better to let the young hatch in the nest and not to remove them until they are about half grown, and they should only be turned over to trustworthy experienced people.

The young of captive parents are usually uncommonly shy, as the adults tend to give alarm whenever the keeper appears. It is worthwhile to tame them even if they are to be hacked back into

the wild later. For this it is important that they have chances to take living quarry as soon as they are hard penned. They don't have to be taught how. European Kestrels which I have hacked back either as nestlings or after rather long captivity have always adapted well and have sometimes delighted us with their visits long afterwards.

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