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SAKER FALCONS IN CENTRAL ASIA

Final Report of the Pilot Study

Contract with:

National Avian Research Center,
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R E KENWARD & R H PFEFFER

Furzebrook Research Station
Wareham
Dorset
BH20 5AS

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SUMMARY

This report is written at the end of a 2-year pilot study of Saker Falcons (*Falco cherrug*) in central Asia. The work included the first experiments to study the movements and survival of falcons released after use for falconry, and the first extensive study of demography, genetics and health in wild Saker Falcons.

Radio-tagged falcons released during March-April in the United Arab Emirates moved rapidly away from release areas, with initial flights typically downwind, such that VHF tags on 7 of 10 falcons were out of range by the second day after release. A satellite location suggested that one falcon may have travelled to northeast Kenya, 2,000 km southwest of the release site. More work is needed to determine the most appropriate release areas, relative to the natural wintering, migration and breeding routes of the falcons, and the most appropriate release times in relation to their natural seasonal movements.

Data from micro-transponder recoveries indicated that at least 10% of young falcons from Kazakhstan reached falconers in the United Arab Emirates, after rings (and radios) had been removed by trappers. Including ringing data, 23% of young females are known to have been captured. At least 13% (possibly 20%) of the other young falcons with radio-tags returned to their natal areas in Kazakhstan the following spring; they were first recorded about 1 month before breeding pairs lay eggs, and stayed for up to 3 weeks. Estimates of proportions trapped and returning to natal areas are likely to increase as recording techniques improve.

The project team marked and took samples from 61 falcons in 1993 and 81 in 1994, at study areas in north, central, south and eastern Kazakhstan. Radio-tags were put on 79 falcons, including 2 young marked with PTTs for tracking of migration routes by the NOAA/Argos satellite system. In 1994, 9 domestic-bred young (7 with radios) were released by fostering with wild broods from which young had been removed illegally. Four adult falcons were also trapped, and 2 of them radio-tagged. Productivity of wild falcons was only 1.9 per pair in 1994, compared with 2.8 per pair in 1993, because of theft and unusually poor weather. Most thefts were in study areas nearest to Almaty. Breeding females at 3 of 17 pairs near Almaty were in 1st-year plumage, a further indication of pressure on this population by humans: in the northern study area, where there were no thefts, no 1st-year falcons bred.

Assistants are now trained to estimate density, assess productivity, take samples, mark and track falcons in Kazakhstan, and good relations established with conservation organisations. Contacts have also been made for extending the work across Eurasia if the project continues. Marking falcons with micro-transponders and VHF radio-tags seems adequate for providing the data needed to build a population model, using comparison of northern and southern study areas to provide data for estimating safe harvest levels. Analysis of biological samples taken in 1993 show that Saker Falcons are not threatened by contamination with residues of pesticides or heavy metal residues in the centre of their geographic range; however differing trace levels of these substances, and findings from work on parasites and genetics, may serve as biomarkers to detect the natal origin of young obtained for falconry.

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1. INTRODUCTION

This report is the product of a 2-year contract, between the National Avian Research Centre in Abu Dhabi and the Institute of Terrestrial Ecology in Britain, to develop techniques for studying Saker Falcons in central Asia. ITE proposed the work in 1992, to assess the Saker's status and harvest for falconry throughout its global range, following the presentation at a conference of data on numbers of trained falcons in the United Arab Emirates (Riddle & Remple 1994). Although Saker Falcons have been harvested for centuries for traditional falconry, with many then being released back into the wild, recent environmental and political developments made it a good time take stock of the resource. ITE therefore proposed (i) to construct a harvest-sustainability model for Saker Falcon populations by using techniques newly developed for rapid measurement of raptor demography by radio-tagging (Kenward 1993), (ii) to mark falcons throughout their range to estimate the size of the harvest in different regions, (iii) to study potential environmental threats (*e.g.* pesticides) and (iv) to investigate how much released falcons could contribute to wild stocks.

Before committing itself to the funding of a project that could gather all the necessary data, NARC decided to commission a 2-year pilot study. The study aimed to test if techniques that had been pioneered on sedentary raptors in western countries could also be applied to a migratory falcon in less accessible areas. NARC's Director of Falcon Research, Dr. Nick Fox, also had on the table at that time a proposal to study relationships between hunting behaviour, morphology and taxonomy of Saker Falcons, by using museum skins and genetic analysis of blood from trained falcons. It was agreed that the field research would be used to gather genetic material of more certain origin than museum skins, as well as veterinary samples for NARC studies of falcon diseases.

A model for sustainable use of a species like the Saker Falcon cannot be developed in less than 5 years. Productivity of nests can be measured relatively quickly, but 4-5 years are required to record age-specific survival rates (1st year, 2nd year, older) even using radio tagging to gather the data faster and more accurately than can be done by ringing. Work for at least 5 years is also needed to record age of first breeding and age-specific productivity, if based on cohorts in a mature population in which individuals start breeding 2-3 years after fledging. These data are needed from both mature and stressed (or expanding) populations for a sustainability model. By starting with a 2-year pilot study, the project was therefore inevitably divided into 2 stages, requiring a further 3 years of work even if the first 2 years made good progress. The full exploitation of such a model, to predict population trends and manage Sakers globally, would require a third study phase.

The next 2 sections of this report describe progress made during the pilot phase of the work. Each section gives the broad approach, the methods used, the results and a summary. The fourth section provides a vision of the second phase, and reports progress relevant to the completion of that phase, followed by recommendations for further progress by NARC and ITE. The appendices provide details of all contributing personnel, equipment purchased, and data from falcon marking and measurements, conventional and satellite radio-tracking and biocide analyses. To conform with NARC policy, no nest locations are reported.

2. RADIO-TRACKING RELEASED SAKER FALCONS

Traditional falconry involves "borrowing" raptors from the wild. Typically, hawks or falcons are trapped on autumn passage. By that time they have already learned some hunting skills, which is important if they are to be flown successfully at prey which are also strong migratory fliers, such as the Houbara Bustard. At the end of the hunting season the trained hawks or falcons would be released, if they had not already been lost. Only the outstanding hunters would be kept, because until recently it was difficult to obtain fresh meat to feed them all summer. Traditional falconry has advantages for conservation, provided that the harvest is sustainable, because it both provides a strong incentive to preserve the wild stocks, and also can be used to monitor the health of those stocks (see section 4).

However, to ensure that trained falcons are only borrowed from the wild, it is important that they are released in a way that maximises their chance of contributing to wild breeding stocks. An important aim of the work has therefore been to investigate how trained Saker Falcons should be released. If the success-rate for their re-establishment in the wild can be estimated, this will form a component of the harvest model.

The fate of released falcons was monitored by radio tagging. The original proposal was to release appropriate falcons in Pakistan. Conventional VHF radio-tags were to be used to monitor movements and survival immediately following release, with new tags for the Argos satellite system as a means of tracking falcons back to their breeding areas. Since release in Pakistan was not possible in either 1993 or 1994, there were 5 birds released each year in the United Arab Emirates. In 1994, tags for tracking by satellite were on 3 of them.

2.1 Methods and Results from 1993

In 1993, the island of Merawah was chosen as a release site. The choice depended partly on a low risk of released falcons being trapped by strangers on the island and partly on the accommodation that could be provided there by His Highness Sheikh Mohammed bin Zayed. Trained Sakers had also been released previously on the island.

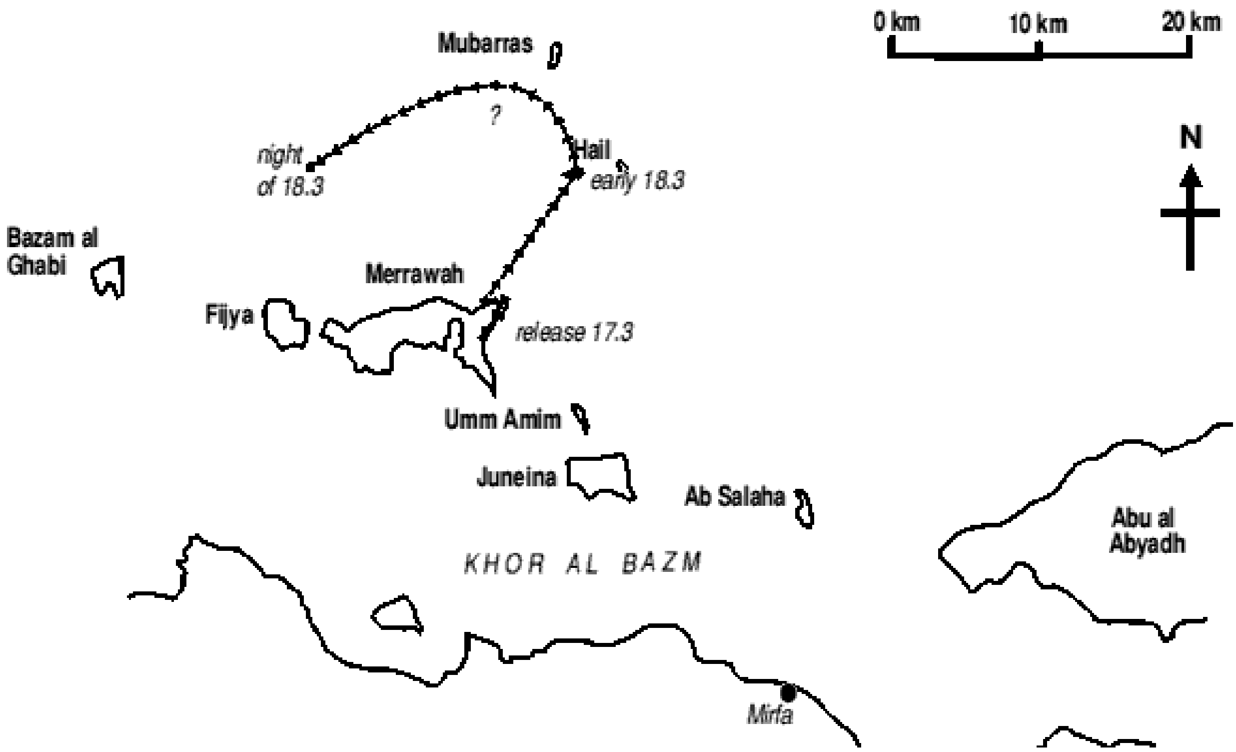
Before any releases, the proposed design for a minimal-sized PTT (platform transmitter terminal) and harness, for tracking by satellite, was tested on tame falcons. Dr. Ken Riddle and Mohammed al Bowardi kindly made their falcons available for the first test. As the length of the proposed PTT design proved too great for use with harness attachment tubes in traditional "fore-and-aft" position, Microwave Telemetry Inc. (Columbia, USA) modified their prototype. These tests also resulted in a new system of lateral tubes being developed for conventional VHF (very high frequency) tags used in Kazakhstan (see section 3.3).

With a 35g tag correctly attached, Dr. Riddle flew his falcon to the lure for several days, and commented that its endurance appeared to be reduced by 25-30%. This was considered to be a result of tag weight rather than fitting: the 35 g tag was about 3% of bodyweight for the female Saker Falcon. The bird initially spent extra time preening and pulling at the harness or antenna when on the block, but ceased after 2 days, and there was no evidence of rubbing when the tag was removed.

The plan on Merawah was to release 3 of the 6 birds with harness-mounted tags, and 3 with 7 g tail-mounts (Biotrack, Wareham, UK). Weighing less than 1% of body mass, the tail-mounts would not be expected to affect flight appreciably, and thus to provide a comparison for the effect of the harness-mount tags. The first falcon, an adult female with frequency number 165, was released at 18.00 on 17 March with a harness-mounted 35 g tag. Each falcon was released onto a specially constructed perch 2.5 m high, with a feeding platform attached 500 mm below the perch. This falcon was given a quail to eat when released. After eating, it flew ca. 1 km to roost on a rocky outcrop by the north-facing shore.

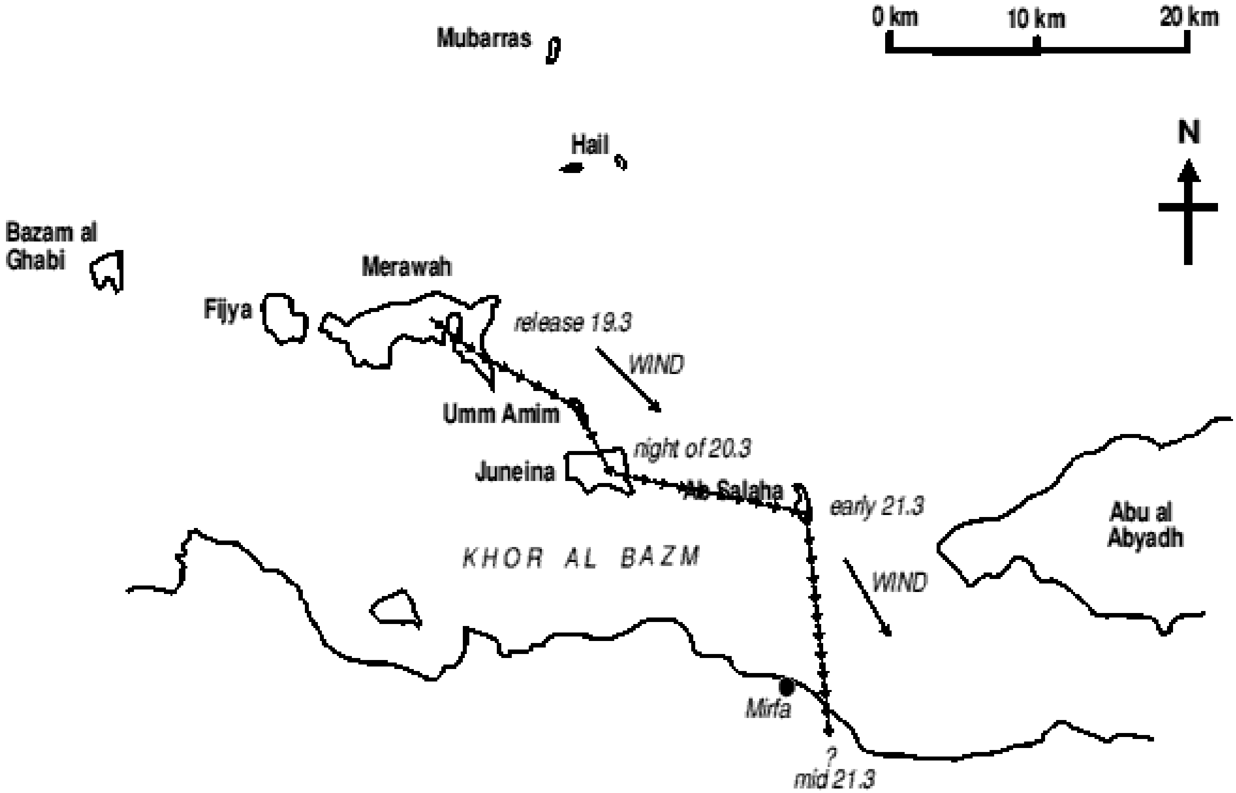
The following morning the falcon was in flight north of Merawah at 07.20, and was considered to land on small islands 18 km from the release site (Figure 1), where there would have been little if any prey. Low tides prevented access by boat to the islands that afternoon, but bearings from further east suggested that the bird had flown north. That evening, the signal could not be heard from northeast Merawah. The following day the signal from this bird was located shortly after take-off from Merawah in a Cessna 172, and after a short search the bird was seen dead in the water about 18 km west of its last known position. It was floating above a sandbank that would have been exposed by the tide the previous evening, and had probably been naively used by the bird as a roost, resulting in its death when the tide rose overnight. The falcon had flown at least 35 km in the day following its release, in winds that were initially from the south. Checks from the air indicated that this tag, and all those on other birds on blocks on Merawah, could be heard from 40 km at 2000 ft, and half could just be detected from 3000 ft at 50 km.

Figure 1. The flight path of harness-tagged Saker 165 from Merawah Island.



Two birds with tail-mounts were released with food at perches at least 1 km apart at 18.25 and 18.40 on the evening of 19 March. One falcon (frequency 146) remained on the island the following day until 12.50, moving up to 2 km from its release site. It then soared away southeast, ignoring waders that flushed beneath it, again with a following wind, along a chain of small islands to roost 10 km away (Figure 2). It was still on that island next day, but left at 10.20 flying downwind, and was recorded in the air long enough to have reached the mainland. Signals from the second falcon (frequency 068) were lost after 07.00 the following morning, while a search was being made by boat for the falcon that had been seen dead from the air. Falcon 068 probably left the island too, since its signal was already weak when heard off Merawah at 07.00, although it remains possible that the tag failed.

Figure 2. The flight path of tail-tagged Saker 146 from Merawah Island.



The last falcon with a tail-mount (frequency 106) was released at 18.20 on 21 March. At 06.30 the following day, it was flying to the northwest but swinging westward, and was last heard on a bearing of 140°. The motion sensor in its tag indicated that the falcon was then stationary, so it was probably on an island to the southeast at that time, but the bird was not located again. None of these birds were detected again from ground level, or from the air in a flight at 3000' on 25 March, which covered the islands southwest of Merawah and about 100 km east along the coast.

One other bird with a harness was released at 18.30 on 20 March (frequency 086), but made no flights longer than about 400 m, and was recaptured 2 days later for examination. This bird had bruising across the body, possibly because it had struggled more vigorously than the others; the harness was also loose enough to have slipped forward and hindered flight. This falcon was therefore retained, along with a 6th falcon with a harness tag that had been rebuilt after the initial tests and was giving weak signals. The results of these releases are brought together in Table 1.

Table 1. Radio tagging and tracking observations on trained falcons released in 1993.

Frequency of tag	165	068	146	086	106
Type of tag	Backpack	Tailmount	Tailmount	Backpack	Tailmount
Released	17/3/93	19/3/93	19/3/93	20/3/93	21/3/93
Release wt.	975 g	920 g	980 g	1040 g	920 g
Immediate behaviour	After eating, flew 1km to boulder roost.	Left feeding at release site.	Left feeding at release site.	Left feeding at release site.	Left feeding at release site.
Next day	Left island at dawn, flew N then W 40 km to sandbank.	Left island at noon, flew out of radio range.	Left island at noon, flew ca 15 km SE to island.	Remained near release site. Made no long flights.	Left island at dawn, flew out of radio range to SE.
Last contact	19/3/93 Drowned.	20/3/93 Flew out of radio range.	21/3/93 Flew out of radio range.	22/3/93 Recovered. (poor tag fit)	22/3/93 Flew out of radio range.

In summary, falcons were first released with VHF radio-tags, to obtain base-line information prior to using the much more costly and untested PTT tags for location by satellite. Three falcons with 7 g tail-mount tags, and 2 with 35 g backpack tags resembling a planned PTT, were released on Merawah between 17 March and 21 March 1993. All the falcons left the island within 2 days, apart from 1 whose back-pack harness slipped forward and hindered flight; at least 2 birds flew downwind to the southeast and probably reached the mainland, but one left northwards on a southerly wind, sought to roost overnight on a sandbank, and drowned when the tide rose. It was concluded that 1994 releases should not be on an island, but immediately south of the Strait of Hormuz if the project could not proceed in Pakistan.

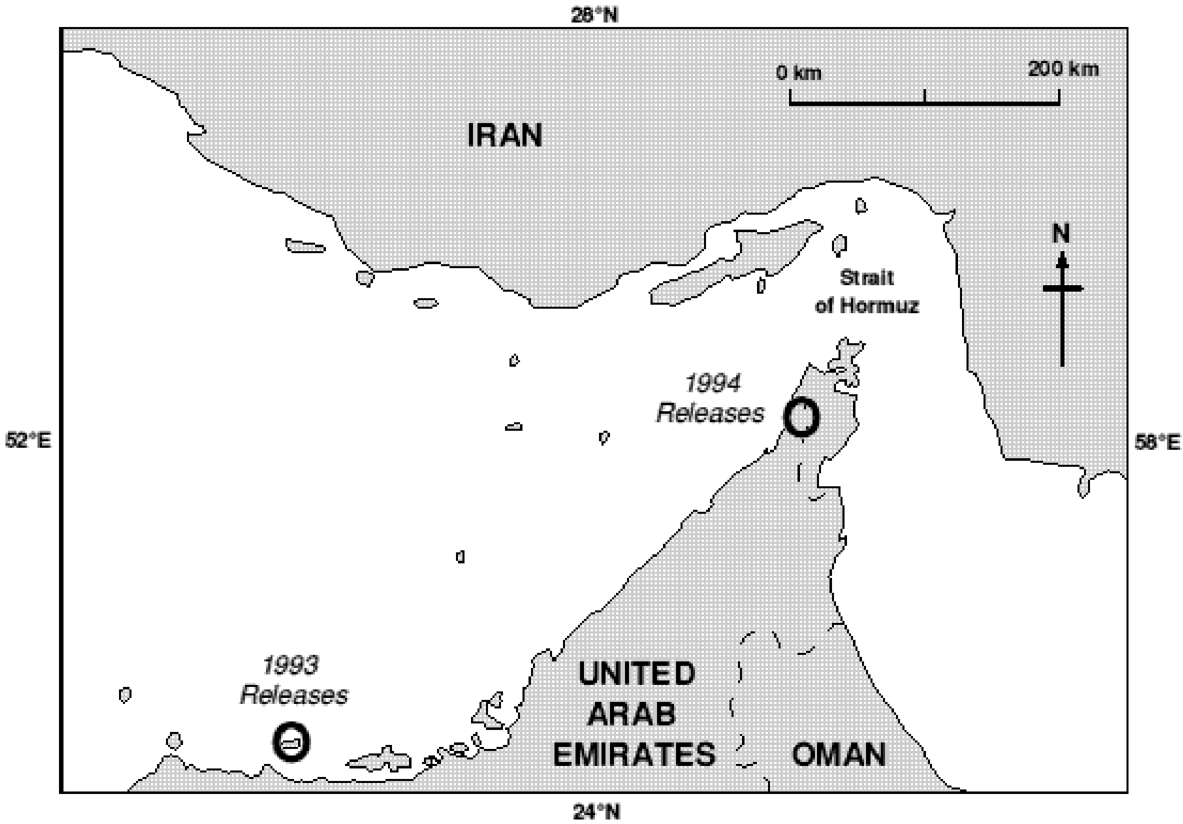
2.2 Methods and Results from 1994

On 22 March 1994, 6 female Saker Falcons weighing 1080-1170 g were equipped with 4 g tail-mount radio tags, designed to give powerful VHF signals for 14 days. PTTs for tracking by the Argos system were also mounted on 3 of these falcons. The PTTs were designed to transmit for 8 hours with intervals of 5 days between transmissions, with a life of 12 months. They weighed 28-30 g, slightly less than had been expected in 1993. Total weight of VHF tags, PTTs and harnesses was 33-35g, 2.8-3.2% of body mass. Similar PTTs were used in 1993 to track 2 adult Peregrine Falcons from the North American Arctic to wintering grounds in South America, in one case in Argentina (Fuller 1994). These peregrines weigh 10-15% less than central Asian Saker falcons.

Plate 1. **A falcon with PTT tag for tracking by satellite at Wadi Sha'am in 1994.**

After checking that signals from the PTTs were being received by the Argos system, the falcon with PTT 20768 was released shortly after a falcon with tail-mount VHF 093, at 17.00 on 25 March. The release site was a blind wadi with surrounding 4-700 m cliffs about 2 km northeast of Sha'am. This was approximately 50 km south of the northmost land on the south shore of the Strait of Hormuz, from which only about 60 km of water need be crossed to the nearest islands on the Iranian shore.

Figure 3. The release sites for trained falcons in 1993 and 1994.



The falcon marked only with VHF tag 093 found updraft and soared up more than 1000 m before being lost to sight over the cliffs in an easterly direction. The falcon with VHF tag 087 and the PTT had more difficulty gaining height, and eventually perched for the night about 200 m up a cliff, 1 km south of the release site.

Plate 2. A Saker Falcon at the Wadi Sha'am release site.

Doubts about health of the falcons necessitated replacement of the 2 other PTTs. The 2 falcons with these, and 1 more with a tail-mount tag, were released on 7 April (Table 2). PTT 20770 was attached to a 1300 g falcon, the largest released, with PTT 20769 on another, and tail-mount VHF 062 on a third. They were released in Wadi Sha'am at 16.00. In this case, no falcon left the valley immediately. The birds with PTT 20770 and the tail-mount alone both soared for a while, but failed to get appreciable updraught and settled 150-250 m up the cliffs, while PTT 20769 remained close to the valley floor.

The immediate impression from these releases was that a falcon carrying a tail-mount tag and a PTT, which together increased its weight by about 3%, could fly for long periods and gain height in updraughts. However, a falcon with a PTT was not as buoyant as a falcon equipped only with a tail-mount tag, which increased its weight by less than 0.4%.

Table 2. Radio tagging and tracking observations on trained falcons released in 1994.

Tags: VHF	087	093	054	074	062
PTT	20768		20769	20770	
Released	25/3/94	25/3/94	7/4/94	7/4/94	7/4/94
Release wt.	1100 g	1140 g	1080 g	1300 g	1170 g
Immediate behaviour	Flew twice, roosted 200m up cliffs.	Soared to >1000m, flew away to east.	Flew weakly roosted near wadi floor.	Soared to roost 200m up cliffs.	Flew twice, roosted 250m up cliffs.
Next day	Not tracked.	Not tracked.	Remained in Wadi Sha'am.	Stayed near Wadi Sha'am.	Flew S out of radio range.
Last contact	At release site on release day No VHF from air on 27/3.	At release site on release day No VHF from air on 27/3.	VHF fix 1.5 km from release site on 8/4.	Argos reports, apparently in Kenya, on 13, 19 & 24/4	Flying S from Wadi Sha'am on 8/4.

The PTTs were reset, to start an 8-hour signal transmission, within 3 hours of each release. Relatively accurate locations (class 1) at the release site were obtained by the Argos system for all 3 birds during that 8-hour transmission, estimating their most likely positions at approximately 26.04°N, 56.15°E. The Argos system uses the Doppler shift in PTT frequency to estimate a location on each side of the satellite track; knowledge of past positions and geography is used to indicate the most likely of the 2 locations. During the following 8-hour transmission, at 05.28 GMT on 13 April, a pair of possible locations was obtained for PTT 20770 at 2.06°N, 40.38°E and 7.37°N, 17.76°E. These were of accuracy category (class 0). A subsequent signal was detected on 19 April, but the Argos system failed to estimate locations because of a software fault. A final signal, inadequate for a location estimate, was received on 24 April.

The location for PTT 20770 at 2.06°N, 40.38°E on 13 April was in northeast Kenya, about 2000 km SW of the release site, whereas the alternative location (7.37°N, 17.76°E) was just south of Chad, some 3500 km from the UAE. Although VHF signals showed that PTT 20770 remained near Sha'am on 8 April, it had left by 10 April, and a migrating falcon can fly 500 km in a day. VHF tracking showed that the other falcon released on 7 April, without a PTT left southward, in winds from the north. Although the falcon with PTT 20770 could not have reached 7.37°N, 17.76°E in the time available, she might have reached Kenya, by travelling southwest along mountain ridges.

This possibility gains credibility from 3 other facts. First, Argos claims that even class 0 locations are very rarely more than 50 km in error, and data from PTTs on nestling Sakers support this claim (see Section 6). Secondly, the tag was nearing the end of its 8 hour transmission when detected by the NOAA satellite, which was above the Sudan (Table 3) and moving south: had the tag been further north, it would probably have been detected earlier that night. Finally, the number of signals received during each pass, which is an index of the signal strength, was least when the satellite was furthest from Kenya and most when it was closest (Table 3). Reviewing these data, Dr. Paul Howie of Microwave Telemetry concluded that there is "a good probability that this bird did go to Kenya". Improbable as such a journey may seem, the falcon with PTT 20770 also had the largest reserves to sustain a long flight. It is not impossible that she reached Kenya.

Table 3. Satellite characteristics and distance from possible Kenya location of 20770.

Date	Sub satellite locations Lat/Long	overhead	Direction from 26N 56E (release)	*N* of signals (strength index)	Distance from 2N 40E (Kenya)
13.4.94	17N,32E	Sudan	SW	2	2000 km
19.4.94	18N,39E	Red Sea	SW	4	1700 km
24.4.94	30N,45E	Iraq	NW	1	3500 km

No transmissions after the release date were obtained for PTTs 20768 and 20769, which indicates either that the tags failed, or that falcons died in locations from which signals are hard to detect. The falcon with PTT 20768 flew strongly when released, but the falcon with 20769 appeared to be weak; it might therefore have been trapped, or killed by predators, and its tag destroyed. Argos system records for these birds are reproduced in Section 9.4.

In summary, 4 of 5 falcons released in March and April with lightweight VHF tags made long flights from the Merawah and Wadi Sha'am release areas by noon the next day, typically downwind. The fifth was not tracked the next day, but had left by the second day after release. VHF tracking indicated that 2 of 4 falcons with PTTs or dummies also left rapidly. Overall, 7 of 10 were out of VHF range from release sites by the second day after release, 2 of the remaining 3 were not flying strongly, and the last falcon may have flown to Kenya. It is unclear whether this restlessness reflected lack of prey in release areas, or a tendency to migrate, but the rapid initiation of long flights indicates the importance of falcons being fit and carrying adequate body reserves when released.

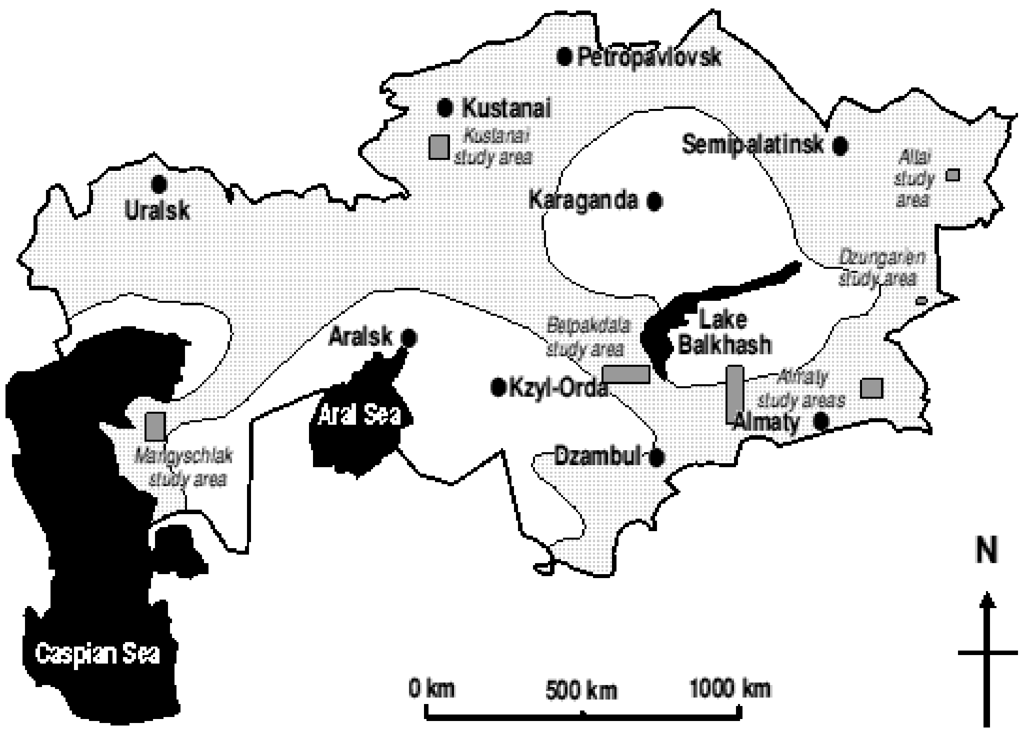
Few data were provided by the falcons released with PTTs. This was partly because of a decision to maximise PTT life by setting a 5-day intervals between transmissions, but it also seems likely that these falcons did not remain long in the wild. It is unclear whether their lack of success was due especially to the relatively heavy PTTs, which might have increased their chance of failing to complete long flights over water, or delayed their departure from release sites and thus made them more vulnerable to recapture by falconers, or critically hindered their hunting. Without the ability to track until the first kills, there is no evidence that the falcons with lightweight VHF tags fared any better than those with PTTs.

3. SAKER FALCON BREEDING IN KAZAKHSTAN

The study of Saker Falcon populations has concentrated initially on Kazakhstan, a country from which ringed falcons had previously been recorded in the United Arab Emirates and Saudi Arabia. It has aimed to develop study areas with a wide geographic spread, partly so that data on demography, genetic relationships and health could be gathered from different Saker populations, and partly to test how easy it would be establish and supervise studies by local biologists throughout the Saker Falcon's geographic range. Marking and registration of productivity would need to continue for several years in many areas in order to estimate regional variation in harvest rates, and density data from diverse biotopes would later be necessary for estimation of Saker population sizes.

Kazakhstan provided an ideal start for such work, because its 3000 km width covers about 40% of the Saker Falcon's longitudinal distribution, from Austria to eastern Mongolia. Moreover, the 1600 km from south to northern Kazakhstan probably covers 70% of the species' latitudinal breeding range. Figure 4 shows the regions where Saker Falcons breed in Kazakhstan, and the 5 main study areas.

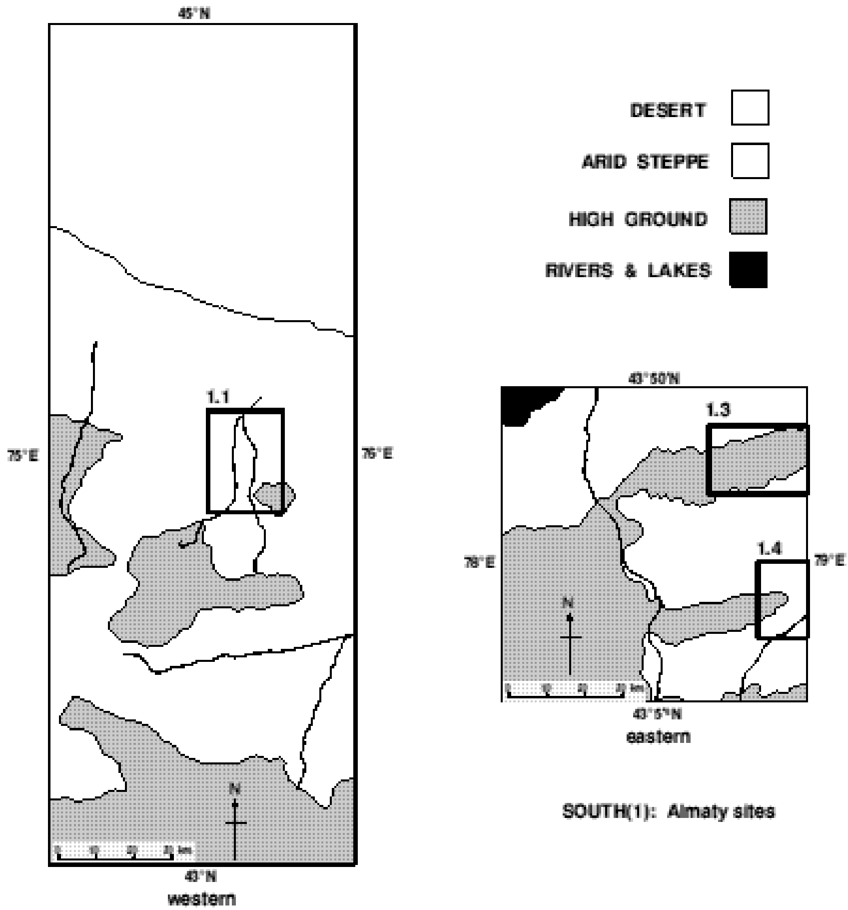
Figure 4. Saker Falcon breeding areas in Kazakhstan (shaded), showing study areas.



3.1 Study areas

Prior to the study, RHP had studied Saker Falcons for 10 years in areas around Almaty (formerly Alma-Ata), the capital of Kazakhstan. He had regularly searched 3 core areas of 260-540 km^2 in which nest density was high (Figure 5, areas 1.1, 1.3 and 1.4), and was confident that all nest sites there had been found. He also had found relatively isolated nests in larger surrounding areas, such that areas of 17982 km^2 and 6723 km^2 could be defined, to the west and east of Almati, in which the error in estimating density would not exceed 20%.

Figure 5. Study areas near Almati in 1993 and 1994, showing rivers and lakes (black), high ground (dark stipple), arid steppe (pale stipple) and desert (white). All nest sites in the core areas (shown by small rectangles marked 1.1, 1.3, 1.4) are known and checked each year, but not in the large outer rectangles.



Although 20 nest territories were known in each of the 2 areas, productivity monitoring and marking of young was restricted to the most accessible sites, of which there were 7 in a core area some 150 km west of Almaty and 15 more about 200 km to the east of Almaty. Only 14 of these 22 territories were active in 1993, and at most 10 in 1994 (when poor weather and shortage of petrol in April made it uncertain if 1 site was unoccupied or had failed early).

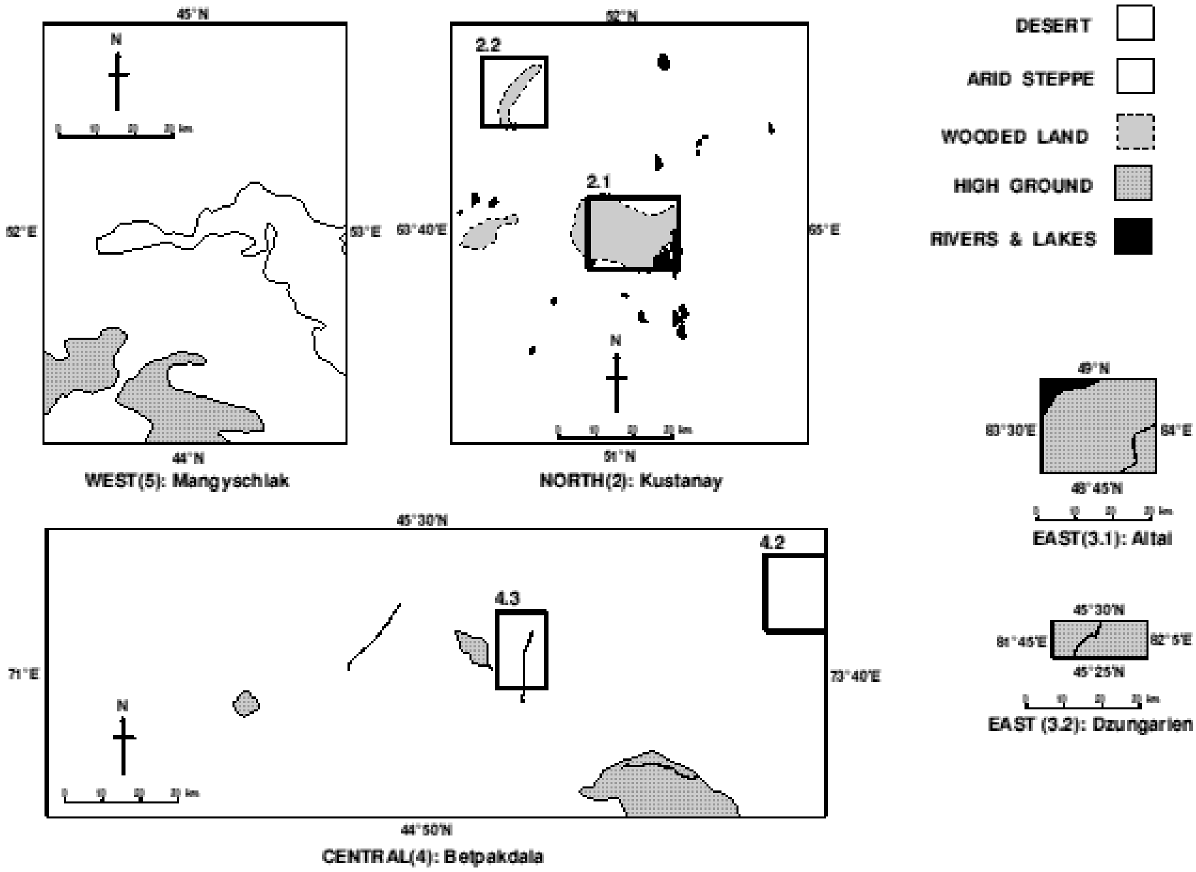
The habitat in both areas near Almaty is semi-desert. The falcons nest on cliffs (Plate 3), and adults are resident throughout the year. Their young fledge in late May or early June.

Plate 3. A cliff nest site used by Saker Falcons west of Almaty.

During 1993 and 1994, expeditions were made from Almaty to seek suitable study areas in 5 other parts of Kazakhstan. A third area contains about 15,000 km^2 of the Betpakdala desert in south-central Kazakhstan, where RP already knew of 8 nest territories and searched further to bring the total to 12, with 3 in each of 2 areas measuring 320 and 260 km^2. The young here fledge shortly after those near Almaty. In 1993, a long expedition was also made to the far west of Kazakhstan. The falcons there favoured tall cliffs topped by scree slopes that made it impossible to fasten ropes safely, and few nests were found because much time was spent unsuccessfully searching more accessible cliffs. Young were seen to be ready to fledge in early May. A further expedition, planned for 1994 with improved climbing techniques, had to be abandoned because of late snow, lack of local support in the west and a severe shortage of petrol due to problems at both of Kazakhstan's refineries.

More successful expeditions were also made to 2 parts of eastern Kazakhstan. Five cliff sites are being monitored, in 750 km^2 of the Altai foothills, where falcons fledge in mid-June. Local support has proved unreliable, but it is planned to extend this area with a new assistant in 1995. In 1994, a second eastern area with 4 nests was developed in 250 km^2 of an unusual upland plateau in Dzungarien, close to the Chinese border, but restrictions on access to this site probably make it unsuitable for further study. Figure 6 shows these areas, together with the most northern study area, which is near Kustanay.

Figure 6. Study areas in western, northern, eastern and central Kazakhstan. In the north, stippled areas with dotted boundaries are woods, other habitats are as in Fig. 5.



The northern study area differs from those to the south and east in being steppe grassland in which scattered southern relicts of the Taiga provide tree nests for fully migratory Sakers. Their nests are typically those built in pines by Imperial Eagles and Sea Eagles (Plate 4), and young fledge in late June. Dr. Yevgeny Bragin, a biologist from the Ministry of Ecology and Bioresources, knew 18 nest sites in 2 parts of a large nature reserve, with at least 2 more nests in surrounding areas.

Plate 4. A tree nest site used by Saker Falcons near Kustanay in northern Kazakhstan.

Nest site characteristics were recorded in all areas. Coordinates and altitude were estimated by a Garmin GPS-100, and aspect measured with a compass. Niche type and position was noted on cliffs, or height and canopy position in trees. These data will be processed during the main study.

It is worth noting that large areas could be assessed only where biologists had already found many sites, such that occupied sites could be identified quickly each year. In this case, a team of 2-3 people could spend 3-4 weeks visiting nests in each defined area early in the season, then search new areas for 4-6 weeks, and finally spend 8-10 weeks marking young and tracking them to dispersal. To find most nests in a new area of about 10,000 km^2 (as in south, central and northern Kazakhstan) would probably take such a team at least one field-season from the ground, although nest detection could be accelerated by aerial survey if suitable aircraft were available.

In summary, the study areas contain cliff-nesting and tree-nesting Saker Falcons, which fledge young from early May to late June. They contain fully migratory falcons in the north, and more sedentary birds in the south. Development of study areas suitable for recording productivity and relationships between density and habitat is satisfactory in northern, central and southern areas, but incomplete in eastern and western areas. Preliminary findings on densities are summarised and discussed further in Section 4.1.

3.2 Productivity Records

Productivity data have been gathered in all areas except the western (Mangyshlak) region. In the southern (Almaty) areas, 14 nests were active in 1993. There was evidence of robbery by humans at 7, and the female had been eaten by an Eagle Owl at one more. Excluding one nest that could not be reached, 21 young in 5 nests were monitored to fledging, including 2 broods of 5 young. In the central (Betpakdala) area, 5 active nests were found, but 2 contained deserted clutches of eggs (which were removed for analysis). The other 3 nests contained 11 young, of which 7 could be marked on 8 June, shortly before fledging. The eastern study area, in the Altai foothills, was visited briefly on 17-18 June. Five of 8 known nests in the area had apparently been robbed by humans. Young at one other nest had already fledged, and we were told that 2 other sites were unsuitable for us, in one case due to accessibility and in the other because chicks were too young. Three northern nests had been robbed shortly before our visit, but those responsible were caught and birds returned to 2 of the nests in time for re-acceptance by the adults. The visit to mark young was timed to coincide with most birds being ready to fledge, and marking was not attempted at 2 nests with slightly older young and 2 with very young chicks. Young could not be caught at all the other nests, but 34 were marked in the north during June 24-26.

Another 7 active nests were located on route to Mangyshlak, bringing the total found in 1993 to 53 active nests among 63 sites checked, but only those in the southern, central and northern study areas were monitored thoroughly enough to provide reliable breeding data. Of the 35 nests monitored in these areas, 8 (23%) failed because of human activity, 2 (6%) were deserted for unknown reasons (possibly poor weather), and 1 (3%) suffered predation. The remaining 24 (68%) fledged young successfully. The number fledged was known at 19 of these, giving a success rate of 4.1 young per successful nest. As 32% of nests failed pre-fledging, the overall productivity was 2.8 (4.1x0.68) young per pair that laid.

In 1994, effort was concentrated on the areas in south, central and northern regions, putting more effort into searching areas peripheral to the core areas. Effort in south and central areas was increased by training a local biologist, Dr. Anatoli Levin, and in the north Dr. Bragin was retained to increase his time monitoring the Saker nests and young. As a result, 4 more active nests were found in the southern and central areas, and despite problems with petrol supplies (such that all petrol for the eastern surveys had to be carried from Almaty) and fewer nests being active than in 1993, 20% more nests had young marked at fledging age in 1994. Data from all areas in both years are summarised in Table 3.

Winter snow and temperatures in early 1994 were the worst in Kazakhstan since 1968, with further snow falling through the incubation period of the falcons throughout the country, and this reduced the productivity of the Saker Falcons. In the north, 4 of 16 sites with falcon pairs present in early May failed to produce broods. In the southern and central areas, 2 of 17 active pairs lost broods for natural reasons. The weather also appeared to have affected brood sizes. The birds that laid produced clutches of normal size, with 3 records of 5 eggs and 4 of 4 eggs. However, by fledging the successful broods contained on average only 3.2 young in the north and 2.0 in the south, compared with 4.1 and 4.2 respectively in 1993.

Table 3a. Saker Falcon nest success and marking data from southern[1] (Almati) study areas. Fledged young per successful nest = "*N*"/"counted"; young per occupied nest = ("*N*"/"counted")x("fledged"/"occupied"); core numbers refer to areas in Figure 5.

Area	Number of nests: checked	occupied	robbed	fledged	counted	Nests with young: N	/succ.nest	Fledged young: /occ.nest	marked
1993									
core 1.1	7	4	2	2	2	9	4.5	1.9	9
core 1.3	6	6	3	3	2	7	3.5	1.3	6
core 1.4	5	3	2	0	0	0	0	0	0
ex-core	3	1	0	1	1	5	5.0	5.0	5
Total	21	14	7	6	5	21	4.2	1.8	20
1994									
core 1.1	7	4	2	1	1	1*	1.0	0.3	*4(7)‡
core 1.3	6	4	1**	2	2	5**	2.5	1.3	4(9)‡
core 1.4	5	1	1**	1	1	2**	2.0	2.0	2(5)
ex-core	4	1	1	0	0	0	0	0	0
Total	22	10	5*	4	4	8	2.0	0.8	10(21)‡

* *Three young were removed from 1 nest by humans after radio-tagging.*

** *Two other nests probably had part of their broods removed by humans.*

‡ *Nine domestic bred young were added to 5 southern nests where 1-2 young remained after robbery by humans. Totals marked, in parentheses, also include 1 trapped adult.*

Table 3b. Saker Falcon nest data from the northern[2] (Kustanay) study area.

Area	Number of nests: checked	occupied	robbed	fledged	counted	Nests with young: N	/succ.nest	Fledged young: /occ.nest	marked
1993									
core 2.1	11	10	0	10	7	27	3.9	3.9	22
core 2.2	7	6	1	5	4	18	4.5	3.8	12
Total	18	16	1	15	11	45	4.1	3.8	34
1994									
core 2.1	11	10	0	6	6	18	3.0	1.8	11
core 2.2	7	6	0	6	6	20	3.3	3.3	20
Total	18	16	0	12	12	38	3.2	2.4	31

Table 3c. Saker Falcon nest data from the central[3] (Betpakdala), eastern[4] (Altai with Dzungarien) and western[5] (Mangyshlak) study areas. Many of the nest sites were not known in advance but found late in the season, so the ratio of "checked" to "occupied" is not a reliable index of occupancy.

	Number of nests					Nests with young		Fledged young	
Area	checked	occupied	robbed	fledged	counted	*N*	/succ.nest	/occ.nest	marked
Central[4]									
1993	5	5	0	3	3	11	3.7	2.2	7
1994	8	7	3	3	3	11	3.7	1.4	11(14)‡
East[3]									
1993	8	8	5	3	0	-	-	-	0
1994	6	6	0	5	5	24	4.8	4.0	16
West[5]									
1993	3	3	-	1‡‡	0	-	-	-	0
1994	0	0	-	-	-	-	-	-	0

‡ *At central sites in 1994, there were 11 young marked and 3 adults.*

‡‡ *Two western nests were not monitored to fledging in 1993.*

Table 3d. Saker Falcon nest success and marking data for all 5 study areas.

	Number of nests					Nests with young		Fledged young	
Area	checked	occupied	robbed	fledged	counted	*N*	/succ.nest	/occ.nest	marked
1993	55	46	13	28	19	77	4.1	2.8	61
1994	54	44	8	25	24	80	3.3	1.9	68(81)
Totals	110	90	21	53	43	157	3.3-4.1	1.9-2.8	129(142)

(Values in brackets include 4 trapped adults and 9 released young marked in 1994)

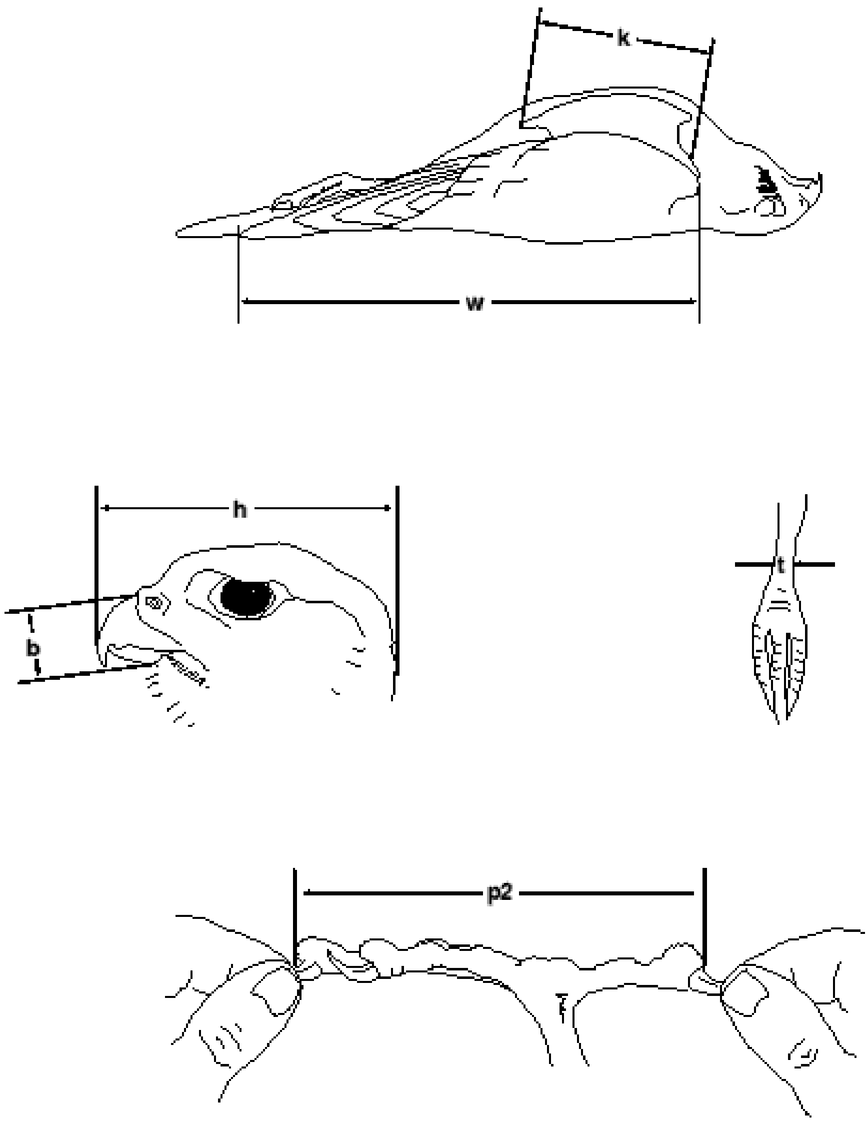
Whereas the unusually poor weather in 1994 appeared to have reduced breeding success by about a third in the northern area, to 2.4 young per breeding site compared with 3.8 in 1993, productivity in the south was half that of 1993, because southern areas also suffered severe human interference. All the young were stolen from 8 of the 17 broods in the southern and central areas, compared with no northern robberies in 1994. At 1 southern nest, 3 young were taken in the week after being radio-tagged, 1 male being left; 2 other nests may have suffered a similar fate, because unusually small broods of only 1 male, and 2 males, remained to be tagged.

Poor occupancy at southern and central areas in 1994 may have reflected a lack of adults rather than bad weather. In the south area, RHP monitored up to 22 nests annually during the 1980s. However, only 14 sites were occupied in 1993, with least breeding in those areas where adults were believed to have been trapped most intensively for export the previous autumn. In 1994 there were at most 10 sites occupied. At 1 of these southern sites the breeding female was in 1st year plumage, with a lone male present near a second. In the central area too, the females at 2 of the 6 sites with eggs were in 1st year plumage.

3.3 Measuring, Taking Samples and Marking

At fledging age, the weight and 8 other measurements were taken from the young falcons (Figure 7). Measurements included length of the wing-chord[w] with feathers flattened, width of tarsus[t] at the narrowest point, length to the distal edge of each toe pad from the hind toe to each front toe[p1,p2,p3], the keel length[k] from the clavicular notch to its distal end, head length[h] and beak depth[b] at the culmen edge.

Figure 7. The measurements taken at fledging. Letters refer to previous paragraph.

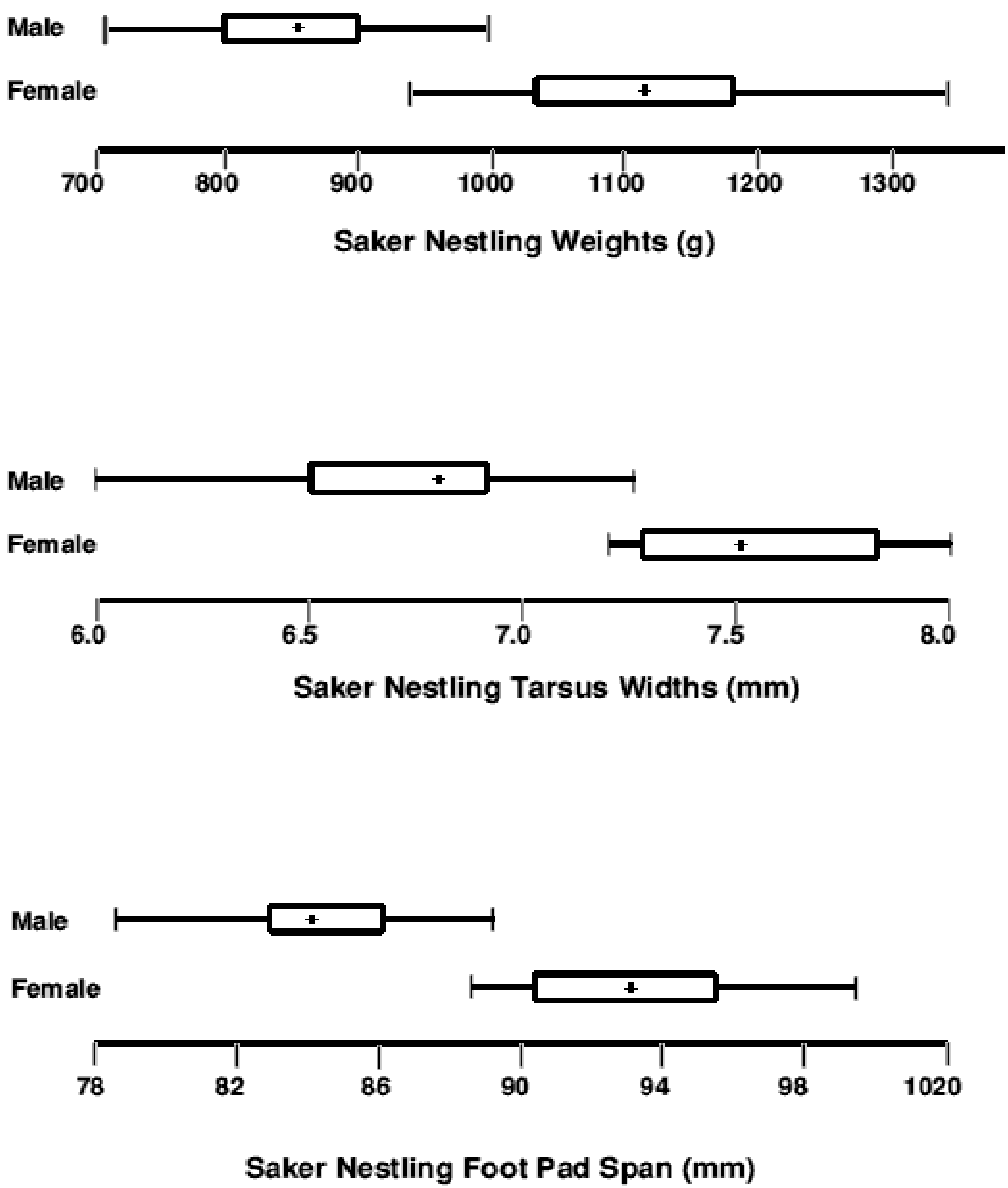


The falcons were also photographed alongside a NARC colour reference card (Plate 5). A 5 ml syringe was used to draw 1-2.5 ml of blood from a brachial vein for genetic, pesticide and blood parasite analyses. A drop of blood was used to prepare a film on a microscope slide; 10 drops were preserved in ethanol and kept with the remainder in ice in steel thermos flasks until the samples could be transferred to a deep freeze. The tip (2-3 cm) was cut from a large wing covert feather for heavy metal analyses, and faecal samples from each nest were stored in 5% saline formalin for veterinary study.

Plate 5. Young Saker Falcon with backpack radio tag and colour reference card.

Birds were sexed subjectively. However, there was little overlap in the weights, tarsus widths and foot span measurements for the two categories, so that modality analyses of the measurements are likely to give the same results, pending confirmation from *post-mortem* examinations. Mean weight was 849 g (S.E.= 9, range 705-990 g) for 55 birds assumed to be male, and 1114 g (S.E.= 12, range 940-1350 g) for 63 birds assumed to be female. Tarsal widths and foot spans, which are usually reliable sex discriminators in dimorphic raptors, were 6.0-7.3 mm and 78.2-89.5 mm, respectively in birds assumed to be male, with 7.2-8.0 mm and 88.6-99.8 mm in birds assumed to female (Figure 8). Sexed subjectively, females were 54% of the young in 1993 and 50% in 1994.

Figure 8. Weights, tarsus widths and foot pad spans of young male and female Saker Falcons at fledging age in 1993: means, 3-quartile boxes and range of measurements.



Measurements tended to be slightly larger for birds in the north, but the only significant difference was in head length. Heads were approximately 1 mm (1.5%) larger in the north ($t = 2.11$ with 85 *d.f.*, $P = 0.038$). This difference might, at least partly, reflect the age of northern birds being a few days greater at marking. Sample sizes are still relatively small, so that differences may become significant in future, but it is clear that size differences between the two areas were not very great.

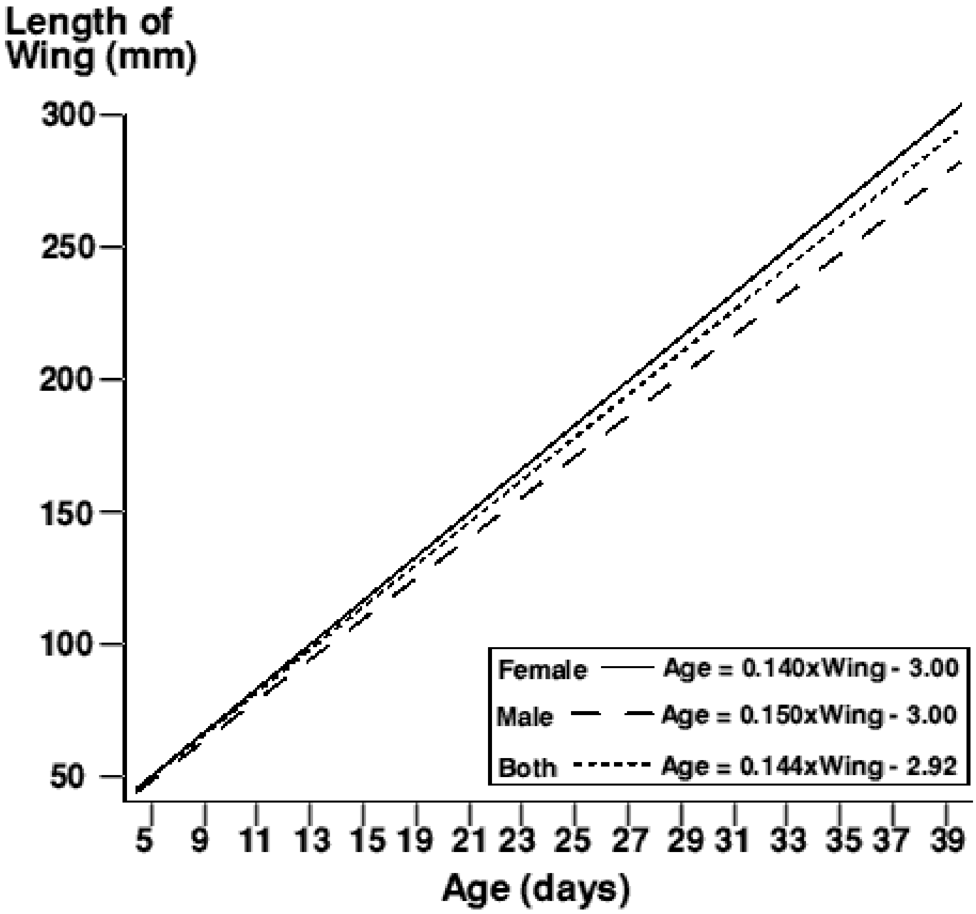
In order to detect movements and capture rates, falcons were marked in all areas not only with conventional rings but also, at the suggestion of Dr. Fox, with micro-transponders for detection by veterinary surgeons in the Gulf states even if rings had been removed. The transponders, from Avid Inc., were inserted subcutaneously to lie above the distal end of the pectoral muscle. In 1993, the transponders could only be read by the Avid system, and their 16-digit code (*e.g.* AVID 001 565 009) was the same as that used to mark falcons in veterinary hospitals. In 1994, the manufacturer was persuaded to supply new tags prefixed by 1111 (*e.g.* 111156486A) to make them immediately identifiable at veterinary hospitals. With the agreement of the British Trust for Ornithology, one of their rings was used on each bird. Kazakhstan has no ringing scheme of its own, and had previously used rings from Moscow. The Institute of Zoology had asked that British rings be used, to avoid the discovery by trappers of nesting areas of birds caught on passage.

In 1994, the ability to capture young falcons was improved by using a "Super-soaker" to wet birds at nests where they were thought capable of flight. In the northern area, this helped capture falcons that could otherwise have flown to the next tree. The effect was shown by the wing lengths of the falcons marked. In 1993 it was estimated that young males could fledge when their wing length reached 300 mm, and young females at 320 mm. In 1993, only 1 of 11 males had wing length greater than 300 m, the average being 271 mm, whereas in 1994 there were 2 of 12 with longer wings and the average was 284 mm. Among 20 females in 1993, the average wing length was 294 mm and only 1 exceeded 320 mm, but 3 of 16 equalled or exceeded 320 mm in 1994 and the average wing length was 309 mm.

Wetting affected the birds in two ways. A gentle wetting of the head seemed to discourage them from flying. One young male on a branch 1 m from the nest ran back and lay down in the nest when sprinkled with water; this bird had probably already flown to and from the nest tree. If birds looked very likely to fly from nests, their main flight feathers were sprayed quite heavily with water to reduce their lift. One male that flew in this condition landed in a tree close to the ground and was caught; his wing length was 321 mm. However, although the water could be sprayed on birds 5-7 m away, it was difficult to wet them from right under a nest, and 2 flew to adjacent trees before they could be wetted. The technique was necessary because as many birds as possible in the northern area had to be marked during a 5-day visit. Dr. Bragin has now been trained to do all the marking and sampling himself, and by measuring wing lengths to estimate fledge dates so that young can be marked at exactly the right time.

Estimation of age is also important for studying behaviour during the post-nestling period, including dispersal from nest areas. In 1994, Dr Bragin measured wing length of 16 young falcons 3-5 times over a period of 18 days. The falcons were all at least 8 days old, and thus in the nestling period for which ITE's work on Common Buzzards has found wing growth to be effectively linear (the regression coefficient, taking individual and sex differences into account, was 0.935, $P < 0.001$), with a difference between sexes just significant (P=0.026). Although data are still required on wing-length at hatch and early growth of Saker Falcons, before feather follicles are fully developed, data on the early period from buzzards were used to produce a graph of wing length against age (Figure 9). The result is relatively insensitive to the small changes likely at the origin, and therefore will probably not change by more than +/- a day when further data are available for Saker falcons. The difference between sexes is also relatively slight while the falcons are still difficult to age, diverging at fledging age by a maximum of about 2 days from the combined line for both sexes.

Figure 9. A graph of wing length growth for predicting age of nestling Saker Falcons.



About 40 young falcons each year have been equipped with 22 g radio-tags (1.6-2.9% of falcon body mass). On the expectation that young falcons would reappear in the breeding areas following migration, the 2-3 year transmissions from these radios are intended to reveal behaviour during the post-nestling period, as well to provide data on survival and first-breeding age for the population model. In 1993, 14 young were equipped with these tags in the southern area and 26 in the north; in 1994 the numbers were 23 and 14 in north and south, respectively.

These VHF radio-tags were mounted as backpacks, using a harness of Teflon ribbon. The harness design enables the loops around the neck and around the thorax to be adjusted quickly at one point (Figure 10). In 1993, tag power output was emphasised, to maximise range. However, tags from birds in tree nests were detected using a hand-held 3-element Yagi from a fire-tower at 40 km across flat ground, so range was deemed more than adequate and tag life has now been increased to 3 years. Detection of flying birds, using a 7-element Yagi mast-mounted on the project's YAZ minibus, should still be possible at up to about 100 km from high points.

Figure 10a. Harness-mounting with lateral tubes. Teflon ribbon is first knotted and glued into the left tag tube adjacent to the antenna and transmitter electronics.

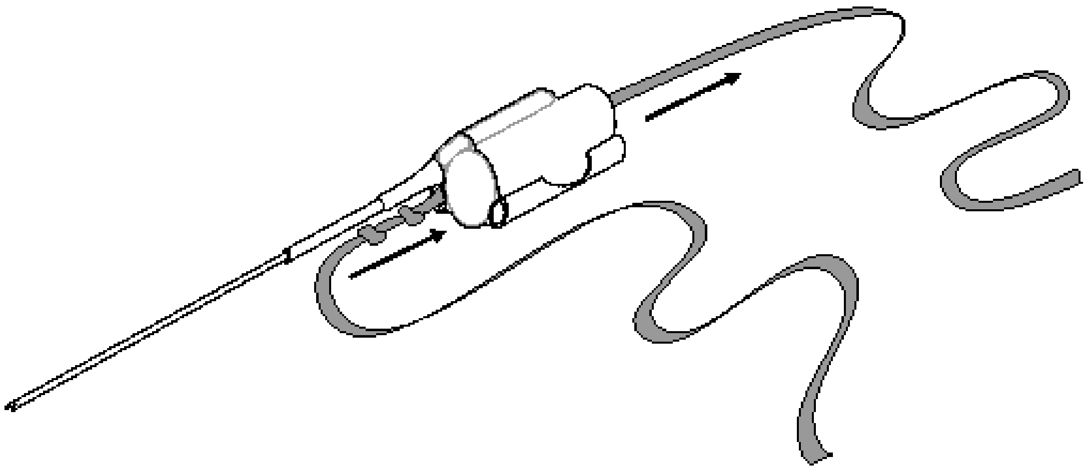


Figure 10b.The body-loop, held by a knot in the right tag tube, is passed over the bird's tail and legs. The neck-loop is then threaded through the breast strap and into the tag.

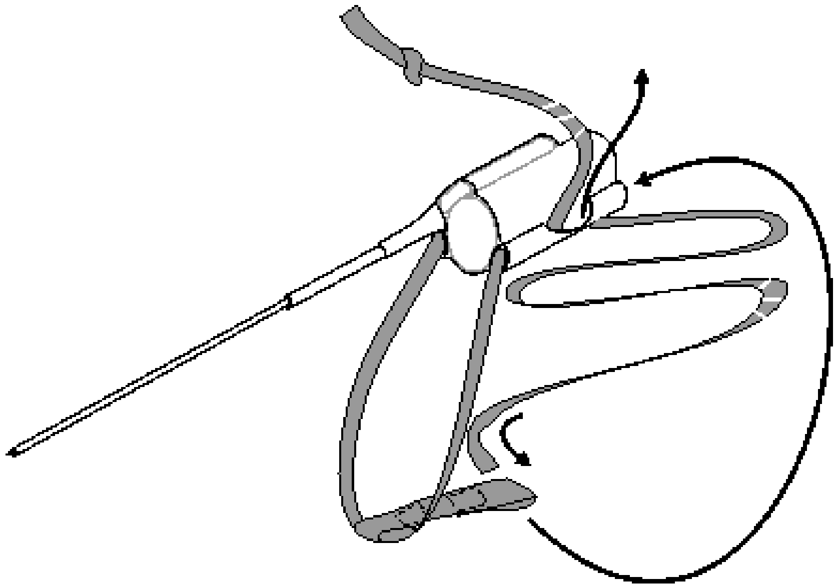
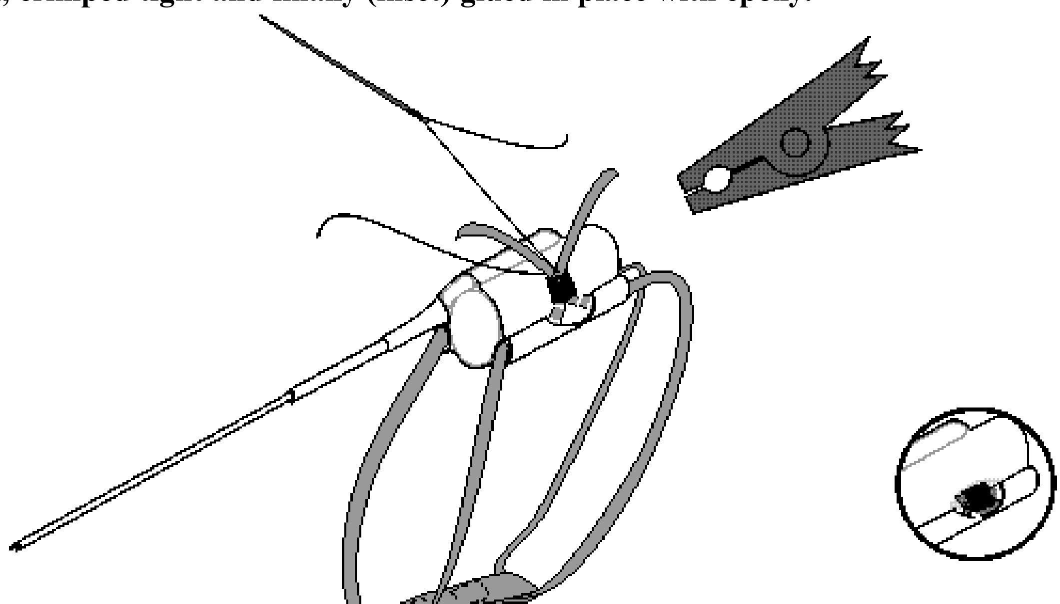
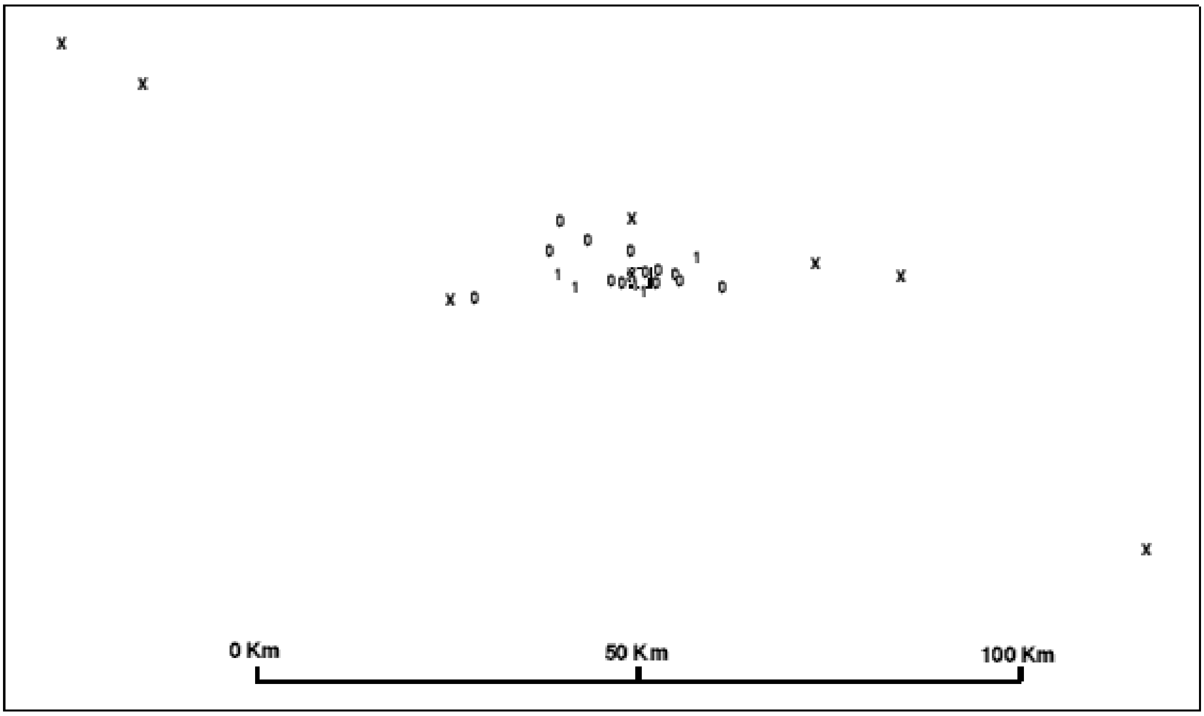


Figure 10c. The ribbon ends are crimped together lightly, adjusted to length with the aid of paint marks, sewn, crimped tight and finally (inset) glued in place with epoxy.



In 1994, 2 young females in a northern nest were equipped with 28-30 g PTTs, which represented 2.4-2.9% of their body mass, for tracking by satellite. By 8 July, 27 location estimates for these birds had been received through the Argos system, which has recently been up-graded to estimate low-accuracy position classes A, B & Z from the poor signals given by small wildlife transmitters. Figure 11 shows the positions of the 27 locations relative to the GPS position of the nest, from which the falcons should not have moved in this period. The mean error of 5 locations with Argos class 1 accuracy rating was 6 km (S.E.=±2 km) from the nest, similar to the 7 (±2) km accuracy of the 14 class 0 locations, although the range of error was lower for class 1 (1-11 km) than for class 0 (1-22 km). The 8 class A, B and Z locations (shown as X on Figure 11) were noticeably less accurate, with a mean error of 40 (±11) km and range of 1-83 km.

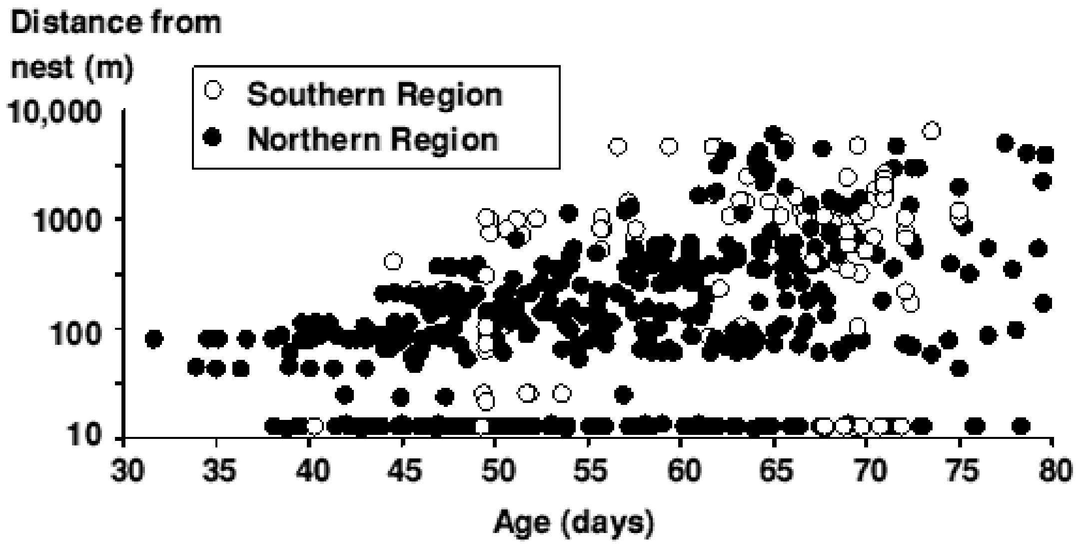
Figure 11. Accuracy of Argos locations for Saker falcons still at a nest in Kazakhstan. A square with 2 km sides is centred on the nest location measured by GPS. Improvement in Argos accuracy is expected from X (Argos classes A,B,Z), through 0 to 1.



3.4 Post-fledging Behaviour and Survival

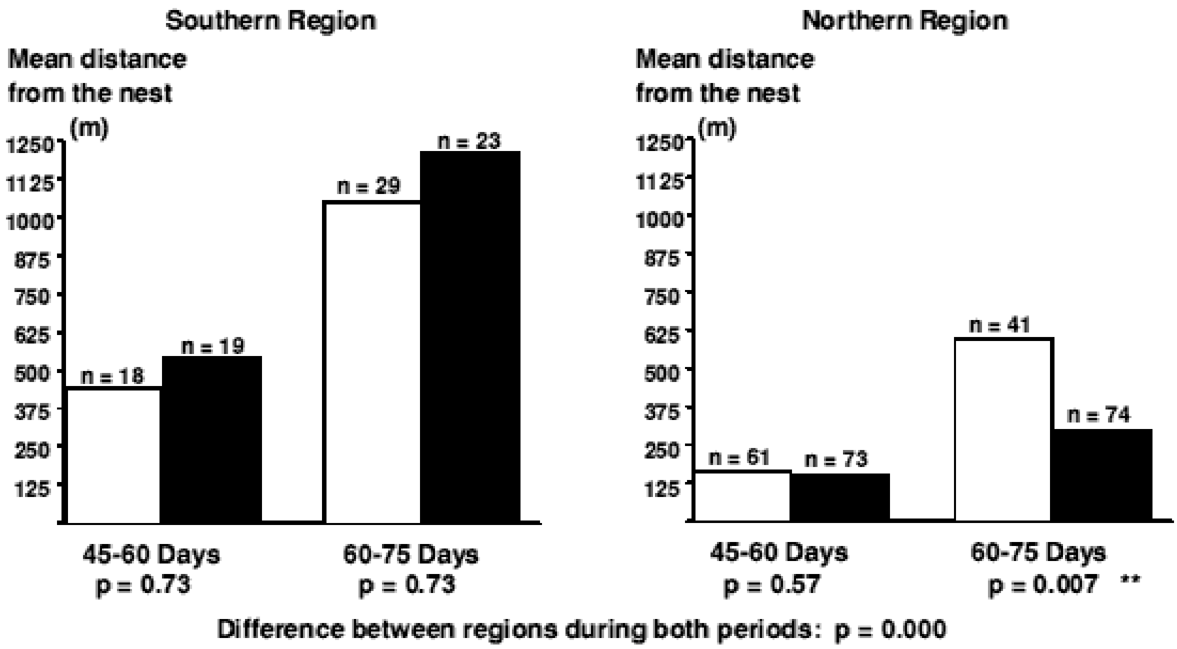
Location records of radio-tagged falcons after fledging were analysed with Ranges IV and Ranges V software (Kenward 1990). Young falcons left the nest from about their 40th day of age, but did not move more than about 100 m away until after their 45th day. Until they were about 60 days old, they generally remained within 1 km of the nest, but thereafter made excursions of much greater distances (Figure 12). The increase in travel at 60-65 days of age also occurs among Northern Goshawks and Common Buzzards (Kenward *et al*. 1993, Walls & Kenward 1994), and probably represents a behavioural change at the time when the feathers finish growth. Before 60 days the young falcons tended to make direct flights, but they could later be watched soaring to considerable height, or chasing each other.

Figure 12. Distances from the nest during the post-nestling period of young Saker falcons in northern and southern study areas. To include long excursions, distances are plotted on a logarithmic scale. Locations at or close to the nest are all set at 10 m.



Distances from the nest were significantly greater in the southern areas than in the north, both before and after falcons were 60 days old ($P < 0.001$). This was probably a result of differences in topography, with hills in the south providing falcons both with a much better view of distant locations and more updraughts to help reach them. In the north, without these aids to flight, males tended to travel significantly further ($P < 0.01$) than females from the nest when they were more than 60 days old (Figure 13). This suggests that the mass of their radios, which was greater relative to body mass for males than for females, was at least less important than other factors in determining their flight behaviour.

Figure 13. The geometric mean distances from the nest of young Saker Falcons in northern and southern study areas, with white columns for males, dark for females.



The locations of the radio-tagged young were recorded at the same time at each nest, so it was possible to investigate their social behaviour. The observed distances between dyads (pairs of individuals) could be compared with the possible distances between them if they used all their perch sites at random, using an index with values from -1 for total avoidance to +1 for total cohesion (Kenward *et al*. 1993). The results, including only dyads with at least 3 pairs of observation, are shown in Table 4, with too few values from the southern area for separate analysis of falcons more than 60 days old.

Table 4. Sociality index values for Saker Falcon siblings in the post-nestling period. Positive values indicate cohesion, negative values avoidance (with sample sizes).

	40-60 days old	>60 days old	Difference
Southern Area	+0.99 (17)		
Northern Area	+0.52 (55)	+0.85 (25)	*P* = 0.034
Difference	*P* < 0.001		

The results show that young Saker Falcons were highly cohesive in the southern area, where they tended to stay together as a family group even when several kilometres from the nest. In the north they were significantly less cohesive than young of the same age in the south, but families became more cohesive with age. These differences probably reflected differences in habitat, but it is not clear whether birds in the south stayed together more because they could more easily see each other in the open country, or because there were relatively fewer separate perch sites than in the wooded northern area. Whatever the cause, the difference between areas within this one species was greater than the difference of either area from Northern Goshawks of similar age, which had sociality indices of +0.59 for males and +0.73 for females. Saker Falcons did not differ significantly in sociality between sexes.

In the south, young falcons tended to move away from the nest in the direction from which adults usually returned with food. At one nest with 5 young falcons in 1993, they moved down the valley containing their nest to roost on a ridge at the junction of another valley, overlooking the plain where the adults would have been hunting. Unfortunately, the second valley contained an Eagle Owl nest, and 2 of the young Sakers were killed by the owls. At another nest with 4 young, 1 radio signal was lost within 10 days after fledging and only 3 young seen thereafter, all with functioning radios. The missing male was killed by a predator that also destroyed its radio, or caught and removed by humans: the nest is near a track, and fledged young can sometimes be caught before they are strong on the wing. In the northern area, one young falcon was killed by an Imperial Eagle, bringing the pre-dispersal losses to 10% of the 40 tagged young in 1993.

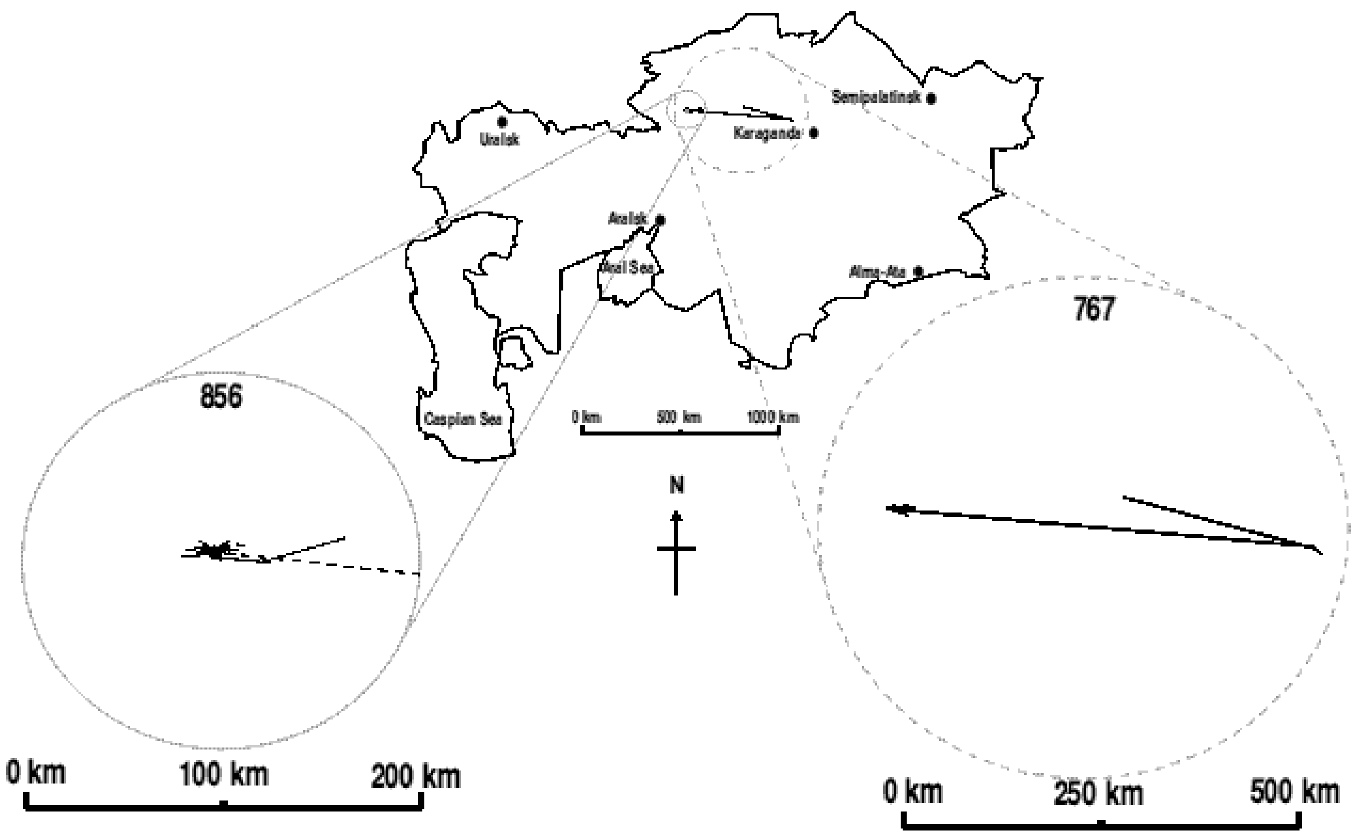
In 1994, a young falcon was found dead without obvious cause in the north, and 2 were killed by predators in the south; they had been eaten by foxes, but may have first been killed by other predators. Since 3 of the radio-tagged falcons had been taken from the nest prior to fledging, the 3 deaths among 34 falcons again represented a mortality rate close to the 10% that occurs among Northern Goshawks and Common Buzzards in the same period.

In 1993, young falcons in the southern area dispersed between 24 June and 7 July. The spread of dates was wider in 1994, with the first dispersal on 17 June, and one bird staying near the nest until 30 July. In the north, dispersal occurred between 23 July and 8 August in each year, with a mean date of 30 July in each case. The length of the post-nestling period was very similar in both northern (33 days) and southern areas (34 days, standard error = 1 day in each case). However, in the south the estimated mean fledging date (31 May) and dispersal date (1 July) were a month earlier than the mean fledging (28 June) and dispersal dates (30 July) in the north.

When dispersing birds were tracked, their movements away from the nest were abrupt.
One was soaring near the nest at 09.23 on 4 July, then recorded flying steadily away in a northwest direction between 14.10 and 16.15, by which time the young falcon was at least 75 km from the nest. Another bird from the same nest was lost similarly in a northwest direction during the afternoon of 30 June, and a third bird was last heard far to the east. Signals from the 8 other birds were simply lost between checks, which were at intervals of 2-3 days: it was assumed that they dispersed mid-way between checks. Despite checks at 1-2 week intervals, the young were not heard again in the study area in 1993, with a single exception: on 16 September, about 12 weeks after its dispersal on 28 June, a male from this area was detected flying through the area again at 16.24, disappearing on a bearing of 305° at 19.27. In 1994, a young male was heard again in October, in a river valley about 200 km from its nest.

Data from satellite tracking provided information on movements of young falcons after leaving their nest areas. The falcon with PTT 20767 moved more than 500 km away to the east of its nest between 30 July and 5 August, remained near Kagaranda for 10 days, and then flew west again towards its nest (Figure 14). A last position for this falcon was obtained on 12 September, after which no further signal was detected. The falcon with PTT 22856 left its nest area between 26 July 1 August, at which point it moved 40 km east. Locations with class 2 or greater accuracy (*i.e.* not more than about 2 km in error) showed the tag moving in the new area until 12 August, but movement then ceased and signals became faint, ceasing when the first snow arrived in October. It may be concluded that this tag was then on the ground, but it is uncertain whether the falcon had died or removed it.

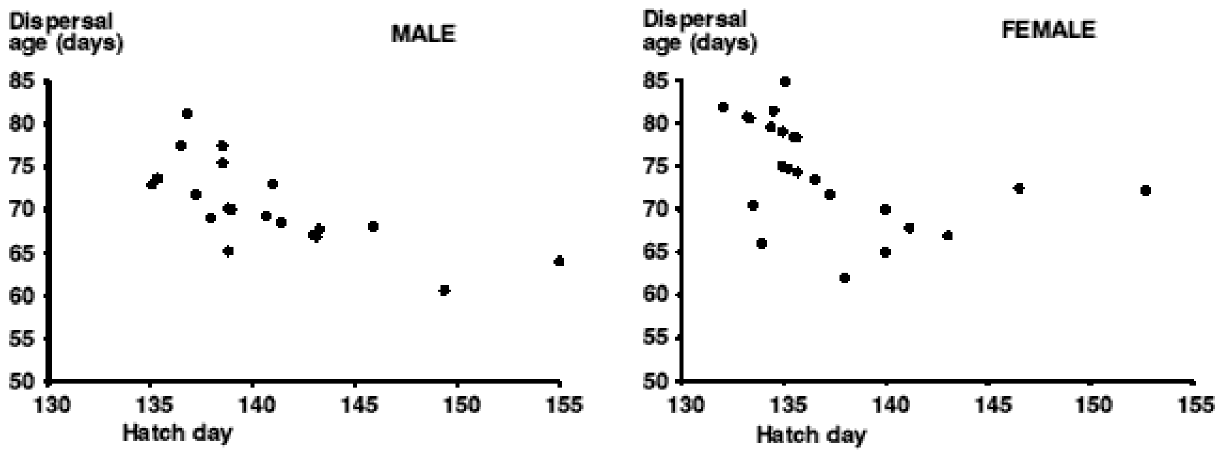
Figure 14. Pre-migration movements, between 1.7.94 and 10.9.94, of 2 young female Saker Falcons tracked by satellite, using observations accurate to at least 10 km.



Young falcons are routinely observed in the northern area until mid-September, and these were previously considered to be local young. However, since all radio-tagged local young had departed by mid August month earlier, it was thought in 1993 that the September observations might be of young on passage from more northerly breeding areas. Data from the PTTs casts doubt on this, because both birds left in an easterly direction, and not the south-westerly direction that might be expected if they immediately migrated. Moreover, birds dispersing from nest territories in the southern study areas also tended to head more east or west than south. It now seems possible that young birds do not migrate immediately after leaving nesting areas, but wander for a while in their summer range before moving south. Such wandering may familiarise them with a wide longitudinal region at the latitude of the nest, which could help them find their way back to natal areas after migration.

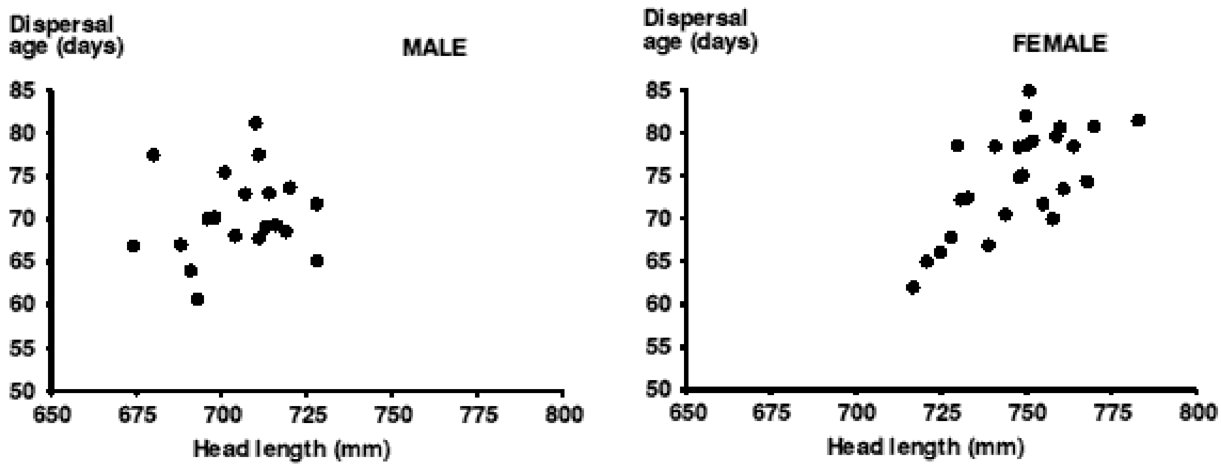
Two factors were found to influence the timing of dispersal. To avoid the compounding effect of differences in area, analyses were confined to birds from the north, where there were larger samples and the timing of breeding did not differ between years. Sakers that fledged late have relatively short post-nestling periods (Figure 15). This effect was highly significant for males (r = -0.71 with 18 degrees of freedom, $P < 0.001$), but less marked for females (r = -0.47 with 25 degrees of freedom, $P = 0.014$).

Figure 15. Sakers that fledged late had relatively less time before they dispersed.



There was also a tendency for the period from estimated fledged date to dispersal to be longest for the birds with the largest heads (Figure 16). This relationship was highly significant among female Sakers ($r = 0.64$ with 25 degrees of freedom, $P < 0.001$), but not among males ($r = 0.15$ with 18 degrees of freedom, $P < 0.5$).

Figure 16. Sakers with large heads had relatively more time before they dispersed.



The tendency of birds fledging late to disperse relatively early also occurs in goshawks. It may mean simply that time of year is more important than age in determining the timing of dispersal, and perhaps also migration in the falcons. The relationship between head length and dispersal age is more intriguing, and may reflect a relationship between morphometry and behaviour, perhaps linked to racial differences that will become more clear with larger samples and quantification of plumage characters.

3.5 Records after Dispersal

The British Trust for Ornithology reported 5 returns from female Sakers ringed as nestlings in 1993. All birds were reported as captive, in Iraq, Pakistan, Syria, Turkey and Yemen. PIT tags were reported from falcon hospitals in 3 falcons, 2 checked in Dubai and 1 in Abu Dhabi. Although the capture locations of all these falcons are unclear, there was also a record of a single male trapped in central Kazakhstan and released again. The PIT recorded in Abu Dhabi corresponded to the ring return from Syria, so the 7 records for females represent 23% of the 30 marked females that dispersed from their natal areas in 1993. Four falcons were from the northern study area, 1 from central Kazakhstan (as was the trapped male) and 2 from the Almati study areas.

At least 5 young falcons radio-tagged in 1993 are known to have returned to their natal areas in 1994, with signals possibly detected from another 3. In the southern area, one young male that dispersed in July1993, and was heard again on 16 September 1993 passing through the study area and away again to the northeast, was found by a farmer under power lines and accidentally killed near its nest in January 1994. This male may not have migrated out of Kazakhstan during winter. Another male tagged in 1994 has remained hunting within 20 km of its nest 1 month after others have dispersed, and RP has previous data to suggest partial migration in the south. On 29 March 1994, a faint signal was heard in the same area from a 1993 female; its location could not be confirmed by a second bearing at the time, but it was located 250 km to the east in the autumn. In the north, signals from 3 falcons were detected on 29 March. Two were still present a week later, and 1 stayed for 3 weeks. Faint signals were believed to have been heard at least once from 3 other tags.

Table 5. Records of radio-tagged 1993 young Saker Falcons after fledging.

	Number tagged	Died before dispersal	PIT-tag/ring recoveries	Recorded in spring Certain	Possible
Male	17	2	1	2	4
Female	23	3	4	3	4
Total	40	5	5	5	8

The detection of 5-8 young falcons in spring in their natal areas showed (i) that the young falcons are philopatric, and (ii) that falcons with backpack radios at 2-3% of their body mass had survived migration. Data from the northern area indicate that first year falcons mainly return about a month before laying occurs, and do not remain long. Other young birds may well have returned to both areas without being detected, because the late, protracted thaw prevented visits to the southern study area in early March, when detection (according to northern data) would have been most likely. In the north, electrical noise associated with damp power lines during the thaw made results of automatic recording unreliable. Future records will be made by fieldworkers staying in each area through the critical period, to make daily personal checks, using the automatic equipment mainly for activity records.

By the time of writing (March 1995), 3 recoveries had been reported for falcons marked in 1994. One, a female marked close to the Chinese border, was detected by Dr. Fox while surveying trapped birds for micro-transponders in the U.A.E., and had apparently been trapped in China. A transponder has again been recorded at the Dubai falcon hospital, from a females marked in the central region, and a radio-tagged male from the northern study area was trapped in Saudi Arabia. Altogether, the recoveries in autumn and winter now represent 5 of the 77 falcons with VHF radio tags (6.5%), a very similar proportion to the 5 recoveries of 59 falcons (8.5%) marked only with rings and micro-transponders. This suggests that falcons with and without radios have similar ability to fly to their wintering areas.

There seems also to be a geographic pattern developing in the recoveries. All recoveries from eastern, southern and central study areas have been from falcons reported to have been caught in southern regions (China, Pakistan). In contrast, falcons from the northern study area have generally been recorded either further to the west (Iraq, Syria, Turkey), or in regions they may have reached on migration along the Red Sea (Saudi Arabia, Yemen). Further recoveries may show whether this pattern reflects differences in migration route. There are as yet no recoveries of the falcons marked in Mongolia. Perhaps these winter in China, away from the normal trapping areas.

4. PROGRESS TOWARDS MODELLING AND MANAGEMENT

4.1 Estimating the Size of Breeding Populations

An important aim of the continuing project is to estimate Saker Falcon numbers throughout the species' global distribution. This can be done in 3 ways. Two use stratified models based on habitat data, the first through mapping discrete categories and the second through multivariate analyses based on GIS data. The third estimates population sizes from mark-recapture data.

The simple stratified approach is to estimate a density that can be applied to all quadrats, of say 10,000 km^2 (approximately 1° longitude by 1° latitude in Kazakhstan), where breeding is considered likely. This is not a simple task, because nest surveys show that Saker Falcons nest locally at quite high densities, of 10-20 pairs 1000 km^{-2} (Table 6, for areas see Figures 4-6 in Section 3). High density areas can be surveyed accurately for nests. However, falcons also have occasional single nests, and therefore much lower densities of 0.1-2 pairs 1000 km^{-2} over much larger areas. A reasonable estimate of numbers in such areas can be gained by examining all suitable nest sites, but it is inevitable that a few nests will be missed. In such areas their breeding density can probably be estimated with 80% accuracy. The survey techniques therefore have 2 degrees of precision: high density areas can be searched thoroughly, but low density areas with less precision. Assuming that the study areas originally selected by RHP have densities somewhat better than average, overall density is probably between 0.1 and 1 pair 1000 km^{-2} for most areas that contain breeding Saker Falcons in Kazakhstan.

Table 6. The main areas surveyed for Saker Falcon nests in Kazakhstan, with density estimates for high precision areas, reduced precision areas, and overall for each area.

	Area (km^2) of precision zone:			Nests in precision zone:			Pairs 1000 km^{-2} in zone:		
Region	high	reduced	overall	high	reduced	overall	high	reduced	overall
1.1	540	17442	17982	7	13	20	13	0.07	1.1
1.3,1.4	728	5995	6723	11	9	20	15	0.15	3.0
2.1,2.2	690	9744	10434	18	2	20	26	0.02	1.9
3.1,3.2	1000	not defined		9	not defined		9	not defined	
4.2,4.3	580	15076	15656	6	6	12	10	0.04	0.8

The final stage in the first estimate procedure is to decide which quadrats might contain breeding pairs, by applying a habitat filter. Density would then be set at the selected figure (between 0.1-1 pair 1000 km^{-2}) for all quadrats thought to contain any breeding sites, and 0 elsewhere, to provide an estimate of the national total of breeding pairs.

Improvements on the first technique involve choosing unsurveyed quadrats in both habitat categories and searching them thoroughly for nests. For psychological reasons, this may be impractical for those quadrats consisting primarily of extensive steppe or desert regions and lacking trees or cliffs, which are therefore considered unsuitable breeding habitat. However, reliability of the breeding population estimate would be much improved by surveying a sample of quadrats considered to contain suitable habitat.

Whereas the first estimation technique relies on simple habitat-filtering, the second approach depends on finding correlations between habitat and breeding density. This could be done through ITE's participation UNEP-FAO projects to classify global habitats at 1km resolution from satellite images. Since the research on Saker Falcons is obtaining density estimates for a number of different areas, it will be practical to seek relationships between density and habitat across these areas. Such relationships can then be applied to remotely-mapped habitat throughout the Saker range, again with testing of predictions in sample quadrats. Such an approach also permits sophisticated modelling to predict future population developments, for example in response to climate change.

The third technique for population estimation does not depend on habitat, but on nestlings being marked, and then harvested for falconry, from areas in which the mean productivity per pair is known. This method also requires that the total numbers of falcons trapped from each region can be estimated, by using genetic or other biomarkers to find the proportion from each region among trapped falcons. Knowing the total number marked in each region, and the number recovered, it would then be possible to estimate the number produced in each region and hence, using the productivity as a divisor, the number of breeding pairs. This approach is discussed further in the following sections.

4.2 Estimating Harvest Rates and Sustainability

As well as estimating population sizes throughout the geographic distribution of the Saker Falcon, this project aims to estimate harvest rates, and to build an "early warning" model to estimate whether harvest rates in different areas are sustainable. Reports of rings and micro-transponders from falcons trapped for training are necessary for estimation of harvest rates. It is clear from the reports in section 3.5 that adequate records are accumulating to make such estimates if the project continues. The recovery rate was 12% for Sakers marked in 1993, with 5 records of rings and 3 of micro-transponders.

Despite the relatively high recovery rate, it is clear that not all rings are being reported. A ringing return was received for only 1 of the 3 falcons with micro-transponders. If there are further records of rings and transponders from the same bird, it will be possible to estimate the reporting rate, and thus the total harvest, from ringing as well as transponder records. This approach would be complicated by changes in the reporting rate. The British Trust for Ornithology provides those reporting rings with information on the country from which the falcon originated, but does not reveal the precise location, and the reporting rate may decline if trappers find such information inadequate.

Transponder records may therefore prove more reliable than those from ringing, which makes it important to obtain as many such records as possible. Through the Middle East Falcon Research Group, Dr. Fox is encouraging vets to scan for transponders in all falcons they treat. Dr. Riddle in Abu Dhabi and Dr. Remple in Dubai have pioneered the marking of trained falcons to simplify treatment records, and scan about 3,000 each year. This veterinary recording is very important for the project, and needs extending as widely as possible. Detection of wild falcon tags by vets should be enhanced by the introduction last summer of transponder codes that differ very obviously from codes used in veterinary hospitals. However, there is now some concern that subcutaneous transponders may be detected and removed by trappers, for fear of prior ownership claims. Pending further veterinary advice, we propose in 1995 to hinder detection by inserting micro-transponders just below a muscle surface.

The estimation of sustainability requires a model of population structure, in order to assess how much attrition (including mortality and trapping) can be balanced by a reduction in the age at which falcons start to breed. For harvesting directed primarily at juveniles, it is also important to investigate possible causes and effects of annual variation in productivity. Such a model requires survival and productivity data for falcons in their first, second and later years from a mature and stable population. These data can be obtained from the northern study area, where 30-40 young falcons can be radio-tagged each year to estimate initial survival rates. The radios will in future last to their third summer, thus providing survival data for the first 3 years; the rate in the third year can be used to estimate the adult survival rate. The radios will also provide data on age of first breeding.

Data on variation in productivity with weather and habitat will accumulate from extending the work into new areas. Regional variation should provide as many data on weather during a relatively short study as would be gathered during a much longer study in one area.

4.3 Trapping Adults and Fostering Fledglings

Additional information on survival of adults, and on first breeding age, will come from trapping adults in the breeding area. Trapped adults will be marked with micro-transponders as well as rings, and it is hoped that a remote recording system can be developed to detect falcons on eggs. It would be relatively simple to place such a recorder for a day in the tree nests of the northern area, to detect whether either the male or the female is tagged. If automatic recording proves impractical, data on first-breeding age and adult survival will come from re-trapping. Following a suggestion by Mohammed Al Bowardi, 2-3 cm of feather will in future be clipped from 2 or 3 inner primary feathers of these falcons. This should render them unattractive to those who might trap them illegally for export, without substantially affecting their powers of flight.

To test techniques for trapping adult falcons at nests during summer, an eagle owl and do-gazza nets were used at 1 nest in the southern area and 3 in the central area. The adult male was caught at one nest, the female at another, and both parents (of which the female was in first-year plumage) at a third. At a fourth nest it was hard to find a suitable place for the trap, and the attempt was abandoned. Trapping was done when the young were well grown, and only the adult females were radio-tagged, because these are not then so essential for the success of the broods. In each case, the females roosted away from the nest after being released, but returned to the nest the following day. If the project continues, trapping will be attempted in 1995 at all nests in the northern area.

In order to estimate the extent to which exploitation can be balanced by earlier breeding, data are also required from a population in which growth or exploitation pressure minimises the breeding age. The present pressure on the population around Almaty should provide these data, provided that sufficient young can be tagged. The high level of nest robberies is making this difficult, but domestic bred local stock could be used to make good the deficit in local production, thereby also supporting the local falcon population until exploitation is regulated.

In 1994, the Sunkar breeding centre kindly provided 9 young falcons bred from local stock for release by fostering. These young were placed, at the point of fledging, with 4 broods from which females had definitely or probably been robbed. Seven of the released young were radio-tagged, and after 2 weeks of radio-tracking they seemed to have integrated perfectly with the remaining 1 or 2 members of each brood. Indeed, when one brood of 2 natural and 2 adopted young split briefly into 2 groups, each group contained 1 natural and 1 adopted young.

4.4 Progress in Biomarker Development: Residue Analyses

The aim of work on biomarkers is to develop a test for blood or feather samples, which can be taken in veterinary hospitals, to identify the region where a trained falcon was raised. By testing random samples of falcons, it would then be possible to estimate the total harvested from each region. In combination with the harvest rate estimated from ring and transponder recoveries, this would provide a check on population sizes estimated from density and habitat data (Section 4.1). Knowledge of origin would be interesting to owners of falcons, and might provide a long-term method of monitoring population trends.

A genetic test of origin would be convenient, but may be difficult for the Saker Falcon. Work in Germany indicates that 3 mitochondrial haplotypes, indicating hybridisation with other falcon species in the distant past, are spread throughout the species' global distribution (Helbig *et al.* 1994, Wink pers. comm.). It is therefore probably necessary to use tests based on nuclear DNA. Tests based on hypervariable (non-coding) nuclear DNA are suitable for investigating familial relationships (*e.g.* Wetton *et al*. 1987), but may be too sensitive to identify the population from which birds originated. The sequencing of DNA regions that code proteins may be most appropriate, but is expensive.

Tests of origin might also be based on differences between natal regions in contamination with organochlorines or heavy metals. Such analyses have been made by Dr. Ian Newton's groups at ITE Monks Wood. Organochlorines were initially analysed in 5 blood samples from the northern study area, and 5 from the south, together with eggs from 2 clutches found abandoned in the central area (Table 7).

Table 7. Organochlorine and mercury concentrations in whole blood from nestling Saker Falcons, and abandoned eggs, which were collected in Kazakhstan during 1993.

	Southern area blood	Northern area blood	Central area eggs
Sample	5 broods	5 broods	2 clutches
p,p'-DDE*	0.024	<0.005	0.070
HEOD*	<0.005	<0.004	0.032
PCBs*	0.012	0.018	0.37
Mercury‡	<0.40	<0.30	0.23

* *Organochlorine concentrations in ppm (parts per million) wet weight. Whole blood averaged 0.4% fat in wet weight, and eggs 4% fat in wet weight.*
‡ *Mercury concentrations in parts per million dry weight.*

Residues of organochlorines and heavy metals in Saker Falcon eggs and nestlings were very low. In several cases, samples were below the threshold for detection, in which case their levels were set at the detection threshold, thus deliberately overestimating the contaminant concentrations (shown as <X). DDE levels in southern nestlings were significantly higher ($P < 0.01$) than in the north, and the levels of PCBs (polychlorinated biphenyls) and mercury were 10-1000 times less than those found routinely in European raptors, but further work would be necessary to discover whether these differences remains consistent enough to identify the origin of trapped falcons.

It is worth noting that adverse effects of contaminants in raptors start to be detected above 20 ppm for DDE (the usual metabolite of the pesticide DDT) and above 2 ppm for HEOD (the cyclodiene pesticides Dieldrin, Aldrin & Endrin), with levels below 5 and 0.5 ppm, respectively, considered low. With levels far below these notional thresholds, it is at least clear that Saker Falcon populations in the centre of their geographic range are not currently at risk from contamination with organochlorines or heavy metals.

Another possible biomarker for different populations would be the consistent presence of different parasites. Veterinary analyses by Dr. Jaime Samour are still in progress.

5. DISCUSSION

Fieldwork on Saker Falcons in Kazakhstan has not been easy. To the considerable logistical problems of providing delicate and valuable equipment for use in remote field areas have been added problems of access due to weather and petrol shortages. In the southern study areas has been added the problem of theft from eyries and winter trapping of adults. Only 7 young fledged naturally from 9 active pairs near Almaty in 1994, with occupancy lost at 5 further sites since 1993. The sustainable yield for Saker Falcon populations has yet to be estimated, but replacement-rate estimates for peregrine falcon populations have generally been close to 1.5 young per pair (Cade *et al* 1988). If breeding adult falcons continue to be trapped near Almaty, and young falcons taken too, any remaining local population will be small indeed.

Nevertheless, the problems near Almaty have also motivated the development of further study areas. These have partly been sought by making expeditions to new areas, which with good planning and fortune can lead to the marking of many young in local pockets of high Saker density. As an example of how successful such expeditions can be, Dr David Ellis assisted NARC's work in 1994 by marking 43 young falcons in Mongolia. Marking young is very important for making harvest estimates, and expeditions can also be useful for obtaining measurements and samples from nestlings. However, such expeditions are much less suitable than trained local biologists for the more sustained fieldwork needed to make reliable estimates of density and productivity. Moreover, expeditions have been most successful (in Mongolia as in Kazakhstan) where there was already some local knowledge, either from other biologists or a previous visit. At present the cost of contracting local biologists in CIS states is lower than mounting such expeditions from western countries. The training of local biologists also benefits indigenous conservation in the long term, and is therefore preferable to external expeditions provided the biologists are trustworthy.

This project has therefore trained local biologists to monitor, mark and radio-track the falcons in the main study areas. In fact, the project has had assistance, full or part-time, from most of the raptor biologists in Kazakhstan, has a good relationship with the conservation authorities, and close links with the embryonic environmental movement. It has also found possible co-operators with knowledge of local raptor populations, who might be trained to estimate density, assess productivity, mark and sample falcons at 6 new locations reaching across the whole of the Saker's longitudinal distribution (Figure 17). In order to provide reliable global population and productivity estimates for this species, we seek to build on the training techniques and goodwill established in Kazakhstan by extending the work across Eurasia.

As well as testing techniques for assessing the status and sustainable yield of Saker Falcon populations, the field research in Kazakhstan has also provided a great deal of behavioural information on a raptor that has been relatively little studied, in comparison with other large falcons. The findings including unique data on relationships between movements, sociality and habitat in the post-fledging period, and an intriguing relationship between dispersal behaviour and morphology.

Figure 17. The current study sites for estimating density, assessing productivity, marking and sampling Saker Falcons in Eurasia (λ), and proposed new sites (O).

Even the problems with weather and the theft of falcons may ultimately benefit the project. The favourable weather in 1993 resulted in excellent breeding results, and breeding is probably seldom affected as adversely by weather as in 1994; in population modelling, data from these 2 years provide useful limits to the natural variation that is likely. Human impact in the south gives the opportunity to study a stressed population, from which data on breeding age can be used in a model from an unstressed population to give yield estimates. The northern study area provides an ideal unstressed population, both because it is easy to warden and also because monitoring adults and productivity is easiest at tree nests. Tree nest sites are probably more common than cliff sites through large parts of the Saker range, so this area also provides useful training for the surveys that will be necessary for habitat-based estimates of population size.

The pressure on Saker Falcon populations in the south of Kazakhstan is also providing opportunities for conservation work, both in terms of population support with domestic breeding and by helping the authorities develop effective regulation procedures. We are now in a position where criticism of Arab falconry, for stressing the falcon populations near Almaty, can be countered with evidence that Arab falconers, through NARC, are also safeguarding this and other Saker populations.

The main inadequacy in the pilot study has been the failure to track released falcons back to breeding areas. Tracking in 1994 suggests that at least 2 birds headed south, perhaps as a result of wind conditions, since falcons headed downwind from Merawah too. However, falcons released in late March and early April might lack a strong tendency to head north, whatever the wind conditions. The radio-tagged wild falcons were back in their natal areas by late March, and left again in early April. The releases took place when falcons should already have returned to their breeding areas, so perhaps their next movement would naturally be southward. The credibility of the location for PTT 20770 in Kenya is enhanced by the subsequent finding that none of the first 27 location estimates for similar tags on young falcons in Kazakhstan was more than 100 km from their true location.

Radio-tracking is particularly demanding during releases. At least 4 of 5 falcons released with lightweight radio tags had left release areas by noon on the day after release, and all 5 by the second day after release. It is therefore essential to track them from dawn on the day following release. The direction of departure can be recorded by tracking from high points; indeed, the detection range from mountain tops should equal the 50-100 km obtained from aircraft to flying birds. If it is desirable to track falcons over greater distances, aircraft must be available for the day after release.

Falcons moved away too rapidly for VHF tags to indicate more than the direction of their departure, and the 5-day interval between UHF transmissions from the PTTs was too long to show what happened to the birds. At present, with 8-hour transmission sequences, a 5-day interval is necessary to obtain a life of 10-12 months from these small tags. This is partly because of poor satellite cover, with the NOAA 11 orbit having decayed such that it is almost synchronous with NOAA 12. In future these satellites should move apart again, and the launch of NOAA 14 should help fill the gap, such that 6-hour transmissions may be adequate. It will also be possible to have 2 duty cycles from the PTTs, such that transmissions could be set daily for the first 5 days after release, and then at 5-day (or longer) intervals, and still obtain a life in excess of 10-12 months. Reliable, long-life PTTs are important for discovering migration routes of wild young falcons from different parts of their range, and could also show whether they fly south again immediately after their first spring return to natal areas.

However, the results raise questions about the safety of using PTTs on falcons. The new harness method was relatively easy to adjust and seems safe, judging by the similar recovery rates for young falcons with VHF tags and without tags. However, as well as being only 70% the weight of PTTs, the VHF tags also had about 40% the volume of the PTTs and tended to lie under the feathers rather than projecting above them. The possible death of the 2 young falcons with PTTs, as well as of the released falcons, means that such tags should be used only with great caution. It would also be useful to conduct more tests to record how much the flying ability of trained falcons is influenced by harness-mounted tags of various weights and shapes.

The release experiments have raised other questions. What, for example, is the best time of year for releases? Would the falcons have been less likely to make immediate long flights if released in January or February rather than late in the migration period? This could be tested by releasing a small number with VHF tags in pre-rich habitat. Where is the best place to release them? We may reasonably conclude that it is wise to release where they can leave easily without need to cross water, and a conservative solution is to release in known wintering grounds. However, might they have maximum chance of success if returned to breeding areas?

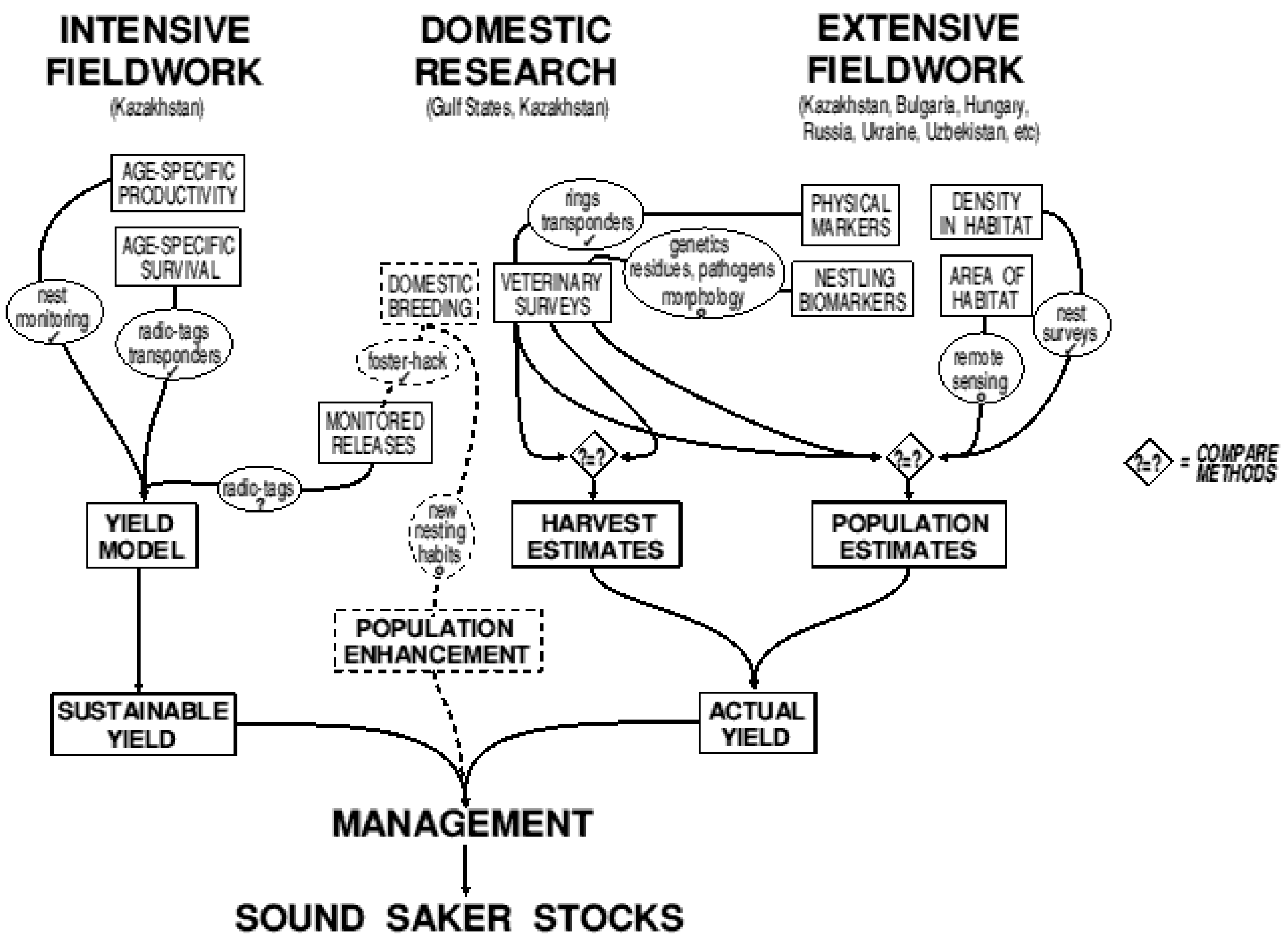
Further work to answer these questions should ideally be done with falcons of known origin, because even if a released falcon returned to a northern area where Sakers breed, it would not be certain that it originally came from that area. The ideal experiment would be to compare return rates to natal areas by releasing some trained falcons (i) close to their natal area, some (ii) in wintering or migration areas, and some (iii) where they have been trained. The radio-tagging of young wild falcons suggests that such work need not rely on expensive and relatively heavy PTTs, because return of released falcons to their natal areas could be detected by checking there for VHF tags. Released falcons need only be equipped with tail-mount tags weighing 8-10 g to give signals detectable at 50-100 km for 3-4 months.

But how could such "known-origin" falcons be obtained in sufficient quantity for research? Return to natal areas can most easily be monitored in Kazakhstan study areas, but taking wild falcons from Kazakhstan is not to be encouraged at present. One solution is indicated by the success in 1994 of fostering experiments with domestic-bred falcons, which came from local stock. Such falcons could be marked beforehand with PITs to prove their domestic origin, and then trapped again for training before they would otherwise disperse. Unfortunately, such a scheme is inhibited by the scope for accusations of laundering.

6. CONCLUSIONS

In Kazakhstan, a great deal has been achieved during the first 2 years of study. Four areas large enough to use in habitat-based population estimates have been established in northern, central and southern regions. Despite problems with fuel, nest robbery and weather, the number of falcons measured and marked increased from 61 in 1993 to 80 in 1994. A target of marking more than 100 young falcons per year is reasonable for Kazakhstan in the future, and there are sufficient ring and transponder recoveries to make harvest estimates. The return of falcons to natal areas in their second spring, suggests that radio-tagging can be used to estimate survival rates, with trapping of breeders used to check the results. Initial results suggest that veterinary and residue analyses may be adequate to determine the origin of juvenile falcons, but more work on these and possible genetic biomarkers is required. In all cases, however, data for several more years will be needed to cross check the estimates and establish confidence in them. This is the aim for the next phase of the work (Figure 18).

Figure 18. The general methods (fine rectangles), specific techniques (ovals) and research targets (bold rectangles) for continued demographic study of Saker Falcons, indicating techniques which seem adequate (√), which have yet to be tested (o) and which are problematic (?). Dotted lines show fields of possible further study.



A particular strength of the proposal is the duplication of methods for reaching research targets. Thus, the total annual harvest of 2,750 falcons estimated by Riddle & Remple (1994) can be compared with estimates based on ring and transponder recoveries. The proportions of trained falcons from different breeding areas, estimated with biomarkers, can be combined with harvest rates and productivity to estimate populations in each area, for comparison with habitat-based population estimates. Although methods cannot easily be duplicated for the yield model, age-specific survival and productivity estimates can be compared with data from other raptors. It remains important to discover the best times and places to release trained falcons, so that they survive and contribute to the wild breeding populations from whence they originally came. Whether such work can be done in the immediate future will depend on access to suitable falcons and release areas.

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8. REFERENCES

Cade, T.J., Enderson, J.H., Thelander, C.G. & White, C.M. 1988. Peregrine falcon populations: their management and recovery. The Peregrine Fund, Boise, Idaho, USA.

Fuller, M.R. 1994. Advances in radio-tagging techniques. Presentation in symposium 54, Radio-tagging in conservation studies, at XX1 International Ornithological Congress.

Helbig, A.J., Siebold, I., Bednarek, W., Gaucher, P., Ristow, D., Scharlau, W. Schmidl, D. & Wink, M. 1994. Phylogenetic relationships among falcon species (genus *Falco*) according to DNA sequence variation of the cytochrome b gene. pp. 593-599 in Meyburg, B.-U. & Chancellor, R.D. (eds) Raptor Conservation Today. World Working Group on Birds of Prey.

Kenward, R.E. 1990. Ranges IV. Software for analysing animal location data. Institute of Terrestrial Ecology, Wareham, United Kingdom.

Kenward, R.E. 1993. Modelling raptor populations: to ring or to radio tag? pp. 157-167 in LeBreton, J.D. & North, P.M. (eds) The use of marked individuals in the study of bird population dynamics: models, methods and software. Birkhauser, Basle, Switzerland.

Kenward, R.E., Marcström, V. & Karlbom, M. 1993. Post-nestling behaviour in goshawks, *Accipiter gentilis*: II. Sex differences in sociality and nest switching. Animal Behaviour 46:371-378.

Riddle, K.E. & Remple, J.D. 1994. Use of the Saker and other large falcons in Middle East falconry. pp. 415-420 in Meyburg, B.-U. & Chancellor, R.D. (eds) Raptor Conservation Today. World Working Group on Birds of Prey.

Walls, S.S. & Kenward, R.E. 1994. The systematic study of radio-tagged raptors: II. Sociality and dispersal. pp. 317-324 in Meyburg, B.-U. & Chancellor, R.D. (eds) Raptor Conservation Today. World Working Group on Birds of Prey.

Wetton, J.H., Carter, R.E., Parkin, D.T. & Walter, D. 1987. Demographic study of a wild house sparrow population by DNA fingerprinting. Nature 327:147-149.

9. APPENDICES

9.1 Contributing Personnel

The biologists listed below have been employed on the project.

Dr. Robert Eyres Kenward, Institute of Terrestrial Ecology, Furzebrook Research Station, WAREHAM, Dorset BH20 5AS, United Kingdom.
Supervision, logistics, fieldwork, training, analysis, documentation. *60 days pa.*

Ralf Heinz Pfeffer, Kolbenzeil 12, 69126 HEIDELBERG, GERMANY.
Fieldwork, logistics, training, translation. *108 days pa.*

Ms. Kathryn Helen Hodder, Institute of Terrestrial Ecology, Furzebrook Research Station, WAREHAM, Dorset BH20 5AS, United Kingdom.
Logistics, translation. *5 days in 1994*

Dr. Yevgeny Bragin, Altinsarina Street 45.I, Kystanayskaja Oblast, Naursymskii Rajon, 459730 KAZAKSTAN
Fieldwork assistance *108 days pa.*

Dr. Anatoli Levin, Institute of Zoology, Kazakhstan Academy of Sciences, Almaty, 480032 KAZAHKSTAN
Fieldwork assistance *108 days in 1994*

The contributions listed are solely for fieldwork on Saker Falcons detailed in this report. They do not include additional work by REK (10 days, 1994/5), RHP (108 days, 1994/5), KHH (10 days, 1994/5) for provision of book chapters on Saker breeding, hunting behaviour and residue levels, nor the work on residue analyses at Monks Wood, nor the many others who have helped without cost to the project. Times are based on a working year of 216 days (*i.e.* 108 days represents work for 6 months).

9.2 Equipment Purchased

The following list includes all equipment purchased for the project, at a cost greater than £100, and still held by the project (thus excluding *e.g.* micro-transponders and radio-tags).

Item	Cost new	Present value (est)
YAZ 452 4-wheel drive minibus	DM13,379	£2000
Telescopic mast & pump system	£1261.28	£600
Repeater compass for mast	£451.25	£270
Masthead and handheld antennas	£481.48	£280
ATS scanning receiver	£1458.00	£870
Data-logging system (incl. receiver)	£1997.50	£1200
PIT readers plus logger	£1555.00	£930
Garmin GPS 1000	£1320.00	£790
Opticron telescope	£414.50	£250
Sony Hi-8 video camera system	£1132.70	£670
Videorecorder for editing	£381.82	£230
Nikon 35mm camera plus lenses	£545.78	£330
Amstrad fax machine	£305.94	£180
Hewlett-Packard portable computer	£1603.88	£960
Disc-drive	£298.46	£180
Hewlett-Packard printer x2	£471.00	£280
Psion Organiser 3a plus RAM card	£469.90	£280
CD-ROM system	£527.69	£315
Camping and climbing equipment	£972.58	£580
Russian-built motor cycle	£300.00	£200

9.3 Marking Data

The following 2 sheets are a print-out of data from all Saker Falcons which were measured, marked and provided tissue samples in the project. Columns, in order, refer to number on blood samples (used with a letter to indicate area), BTO ring number, radio frequency (kHz at 216 MHz), transponder code, area code (11-14 south, 21-23 north, 31-32 east, 41-43 central, see Figures 4 & 5), nest code within area, marking day, month, year, sex (1 male, 2 female), age (1 pullus, 2 adult), weight, wing length (chord), head length, beak length, sternum length, tarsus width, and toe-pad spans (pad 1 inner, pad 2 central and pad 3 outer). See Section 3.3 for further details of measurements, and Section 3.4 for some analyses using the data. In 1994, falcons marked in areas 11, 13 and 14 on 2 June, 4 June and 13 June were from domestic breeding. They were older than wild young, and only their weights were recorded.

Veterinary samples from these falcons and their nests have been provided to NARC in Abu Dhabi, photographs are being provided to NARC Falcon Research Centre in Wales, and blood for genetic analyses is stored at ITE Furzebrook. The data-base is available on disc in MINITAB, LOTUS or ASCII text. To conform with NARC policy, no nest coordinates are given, but are held by ITE.

(These data are excluded to save space)

9.4 Radio-tracking Data

The following 3 sheets are a print-out of a data from the ARGOS location system for 3 Saker Falcons fitted with PTTs and released in the UAE in March and April 1994. See Section 2.2 for further details.

The next set of 2 sheets are printout of RANGES files containing all AGOS locations recorded for 2 female nestling Saker Falcons marked with PTTs in June 1994 in northern Kazakhstan. The columns are PTT code, age, sex, month and year labels, nest coordinates in thousandths of a degree (displaced in longitude and latitude from their true positions), ARGOS location coordinates (similarly displaced), day, month, year, hour and minute of location, and accuracy code (1=A, 2=B, 3=0, 4=1, 5=2, 6=3). The files are available on disc in RANGES V or ASCII column format. They were used for analyses in Sections 3.2 & 3.4.

The final 14 sheets in this appendix are printout of RANGES files containing radio-tracking data of all radio-tagged young Saker Falcons. The format is the same as the previous sheets, but place and behaviour codes qualify each location instead of accuracy codes. Place codes are 0=nest, 1=ground, 2=perched below skyline, 3=perched at skyline, 4=flying. Behaviour codes are 0=still, 1=feeding, 2=hunting, 3=playing, 4=direct flight, 5=soaring. In each case -9 represents missing data. These files are available on disc in RANGES V or ASCII column format, and were used for analyses in Section 3.4. All coordinates are displaced in latitude and longitude to conceal nest locations.

(These data are excluded to save space)

9.5 Residue Analyses

The following appendix is data from analyses at ITE Monks Wood of organochlorine and heavy metal analyses in eggs and blood of Saker Falcons in Kazakhstan. The results are summarised and discussed in Section 4.4.

(These data are excluded to save space)