Ökol. Vögel (Ecol. Birds) 10, 1988: 203-217

On the ecology of the Red Shining Parrot *(Prosopeia tabuensis)* on the Tongan island of 'Eua, southwest Pacific

Zur Ökologie des Pompadoursittichs *(Prosopeia tabuensis)* auf der Tonga-Insel 'Eua im Südwest-Pazifik

Von **Dieter Rinke**

Key Words: *Prosopeia tabuensis*, habitat, population density, food, competitors, habitat alteration, conservation, Tonga, southwest Pacific.

Summary

RINKE, D. (1988): On the ecology of the Red Shining Parrot *Prosopeia tabuensis* on the Tongan island of 'Eua, southwest Pacific. Ecol. Birds 10, 1988: 203-217.

On 'Eua, Red Shining Parrots inhabit all types of forest habitats and plantations which are interspersed with forest remnants and secondary growth. The population density is highest in the forests of the east with between 32 and 51 individuals per km^2; the total number of parrots on the island was estimated at a minimum of 773 birds. Red Shining Parrots mainly feed in the canopy of forest trees. The fruits and seeds of 31 species of plants were identified as food, with the fruits of *Myristica hypargyraea*, a nutmeg congener, being most important.

About 20% of feeding activity was observed at the fruits of introduced plants, but the parrots' impact on crop fruits is very slight. Fruit feeding species are well represented in the avifauna of 'Eua, and the largest of these, i.e. fruit bats and Pacific Pigeons, compete for food with Red Shining Parrots. Competition for nest sites is very slight; and there are no native predators on 'Eua.

Red Shining Parrots have been introduced into 'Eua prior to European contact. The historical changes in its population numbers and its ecology are analysed, suggesting a marked decline in parrot numbers due to habitat destruction since the late 1800's. Man's impact became alarming after 1940, and the forthcoming habitat destruction will certainly reduce parrot numbers to a critically low level.

Zusammenfassung

RINKE, D. (1988): Zur Ökologie des Pompadoursittichs *(Prosopeia tabuensis)* auf der Tonga-Insel 'Eua im Südwest-Pazifik. Ökol. Vögel 10, 1988: 203-217.

Pompadoursittiche kommen auf 'Eua in den verschiedenen Waldhabitaten und in Plantagen, die von Waldresten und nachwachsender Sekundärvegetation durchsetzt sind, vor. Ihre Häufigkeit nimmt mit zunehmender Entfernung von menschlichen Siedlungen und abnehmender menschlicher Aktivität in Plantagen zu. Ihre Dichte ist mit 32-51 Individuen pro km^2 in den Wäldern der schwer zugänglichen Ostküste 'Euas am höchsten. Die gesamte Population wurde auf mindestens 773 Individuen geschätzt. Die Nahrungsaufnahme erfolgt größtenteils in den oberen Regionen des Waldes; an Waldrändern und in Plantagen können Pompadoursittiche aber auch in Bodennähe fressend beobachtet werden. Die Früchte und Samen von 31 Pflanzenarten wurden als Nahrung identifiziert, das sind mehr als 10% der höheren Pflanzenarten 'Euas. Hauptnahrungspflanze ist *Myristica hypargyraea*, eine Verwandte der Muskatnuß. Etwa 20% der Nahrung bestand aus den Früchten eingeführter und eingeschleppter Pflanzen; aber der Schaden an Kulturpflanzen ist gering.

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Die wichtigsten Nahrungskonkurrenten der Pompadoursittiche sind der Tonga-Flughund und die Pazifik-Fruchttaube; dagegen gibt es zwischen den Sittichen und den kleineren Fruchtfressern, die in der Avifauna 'Euas überproportional vertreten sind, kaum Konkurrenz um Nahrung. Ebenso gering ist die Konkurrenz um Nesthöhlen. Pompadoursittiche haben auf 'Eua keine ursprünglich heimischen Raubfeinde.
Die Art wurde vor den ersten Besuchen durch Europäer auf 'Eua eingeführt; bei der Gründerpopulation dürfte es sich um entkommene Individuen gehandelt haben. Nach einer Wachstumsphase und einer Periode stabiler Populationsgröße setzte der Rückgang der Pompadoursittiche mit dem Anlegen größerer Plantagen durch weiße Siedler Mitte des 19. Jahrhunderts ein. Eine Phase gravierender Habitatänderungen, und damit eines beschleunigten Bestandsrückganges der Sittiche, erfolgte seit Mitte dieses Jahrhunderts. Dieser Trend setzt sich offenbar fort, und der Bestand des Pompadoursittich könnte schon in naher Zukunft unter eine für die Existenz der Population kritische Individuenstärke absinken.

1. Introduction

Pacific islands birds have been little studied in the field despite the many associated advantages such as well defined study areas and populations, permanent presence of the study subjects, and limited ecological interrelationships due to depauperate biotas. In the tropical South Pacific (with the exception of the Hawai'i islands) the only long-term study of the ecology of an island bird species is of an introduced species, the Red-vented Bulbul *Pycnonotus cafer* (WATLING 1977). Very little field work has been conducted concerning native species and most of these covered short periods of time *(Lamprolia victoriae:* HEATHER 1977; *Megapodius pritchardii:* TODD 1978; *Didunculus strigirostris:* BEICHLE 1987).
The Red Shining Parrot *(Prosopeia tabuensis),* a member of an endemic Fijian genus, is at present distributed on some larger Fijian Islands and on the Tongan island of 'Eua. It has very probably been introduced into the latter (LAYARD 1876b, AMADON 1942), and its distribution in the Fijian archipelago may have been modified by human inter-island transfers. The previous knowledge of the biology of the species is based on chance observations.
This paper presents the ecological findings of my research on the population of the Red Shining Parrot on the Tongan island of 'Eua from March 1983 to August 1984, i.e. habitats, population densities, food and feeding behaviour, and interspecific relationships. Special emphasis is laid on the historical aspects of the parrot's ecology – changes in habitat preference, in the use of food plants, in population density, and in competetive pressures; and man's role in these changes is discussed. An understanding of the historical process may give insight into ecological trends, which may enable us to identify the threats to this, and probably other, island species.

2. Methods and study area

The island of 'Eua was roughly classified into habitat types by visiting all 1-km^2-squares (based on the 1:20 000 Tonga GVMT. map, 1975) and this classification was improved during the course of the study. The main woody plants (trees, bushes and vines) were identified and allied with certain habitat types (descriptions in RINKE 1987a). I used YUNCKER (1959) and WHISTLER (1981) as references to identify plant species and plant communities.

I estimated population densities in five different habitats (number of counts: 10). Parrots were counted along transect lines (method 1; cf. Verner 1985, p. 269), and the density of individuals per km² was calculated by $N = \frac{n}{L * E}$, where »n« is the number of birds heard or seen along the transect line, »L« is the length of the transect line, and »E« ist the estimated range of detection either by sight or sound which depends on habitat (This is a modification of method 3, cf. Verner 1985: the main belt was estimated after recording the data). Double counts were largely avoided by observing the direction of movements of the parrots. »N« represents a minimum density number, because »n« probably was the minimum number of birds heard or seen during the count, and »E« was estimated rather generously (Red Shining Parrots are very conspicuous, especially their call, and may be detected over long distances). A maximum density could not be calculated by this method.
Whenever feeding birds were seen, an attempt was made to record the following items: species of fruit or seed, number of birds occurring at one site, foraging height and time. A tree, bush, or vine species was identified as a food plant of the parrots when remains of fruits or seeds were found on the ground above which parrots had just fed. In addition, the feeding behaviour of 8 parrots (2 adults and 6 juveniles) was observed in two aviaries on 'Eua. The majority of feeding observations was recorded from the east central part of the island, the study area during the breeding period (Rinke in press), and hence may not be representative of the island as a whole.
The geophysical characters of the island of 'Eua were described by Hoffmeister (1932). An account of its flora, fauna, plant communities, habitats, and climatic conditions are briefly presented elsewhere (Rinke 1987a, 1987b), along with a map showing the main topographic features of the island and Tongan place names.

3. Results of field and literature studies

3.1 Habitats and population densities

Red Shining Parrots were found in all forest habitats, and in plantations and secondary vegetation with significant forest remnants. They were occasionally encountered in intensively worked plantations and low secondary bush (fig. 1.a). Parrot density decreases with the proximity of human habitation and the intensity of human activity; it increases with growing distance from villages and with decreasing human activity in plantations. Human presence has adverse effects on forest cover and the percentage of forest remnats within plantation areas: the relatively inaccessible terraces and slopes of the east coast are heavily forested (Rinke 1987a), and approaching the east coast one finds a growing proportion of forest trees in plantations.
Red Shining Parrots are fewer in forests in the north of the island, and considerably fewer in the north-western coastal and western ravine forests than in the eastern forests. Fragmentation and isolation from the large central forest tracts, a consequence of plantations and very low secondary growth, probably cause the lower numbers in these areas. Food and potential breeding sites seem to have little effect on parrot densities, although the bird's rarity in the northern coastal forest may be due partially to the lack of *Myristica hypargyraea*, its most important food tree on 'Eua (see below). *Myristica* is the dominant tree in coastal forests of the west, south and east, sometimes forming pure stands.
Many parrots, even forest-dwelling species, aggregate in areas where fruiting trees occur (Forshaw 1973, Joseph 1982, Roth 1982). Numbers of Red Shining Parrots in plantations were higher at times when Tongans were not working, e.g. on Sundays and in the early morning, than during the daytime from Monday through

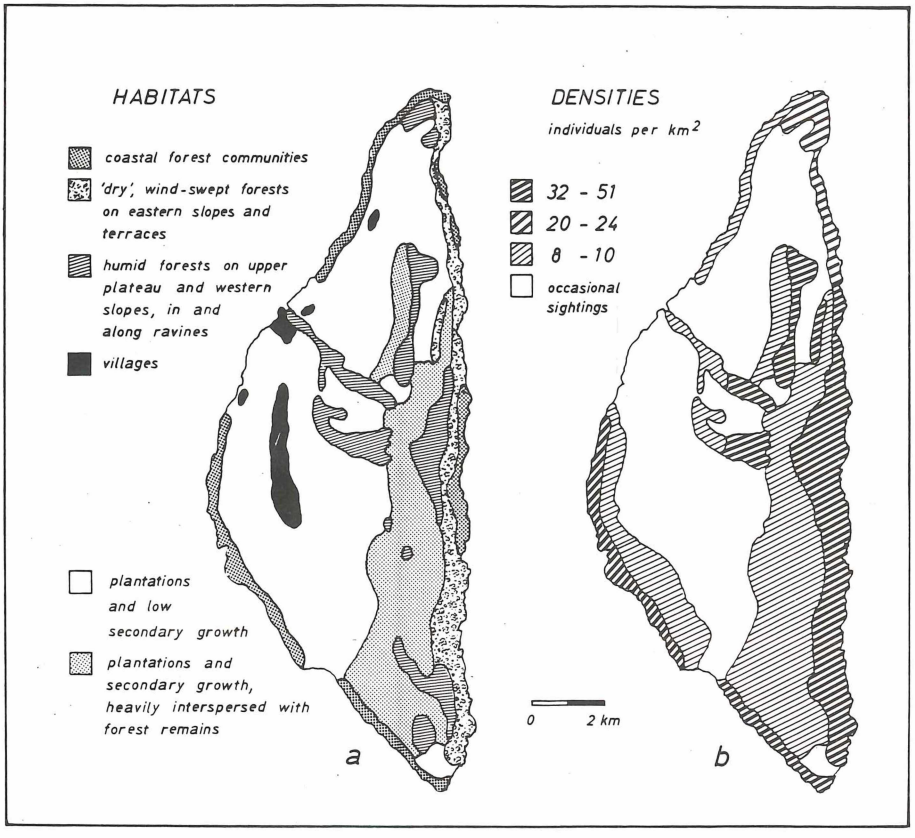

Fig. 1. Distribution of habitats and population densities of Red Shining Parrots on 'Eua. (The densities in both the western ravine and northwestern costal forests where no counts have been made were considered the same as in plantations with forest remnants due to limited extension and isolation of these areas).
Abb. 1. Verteilung der Habitate und Populationsdichten (Für die isolierten und kleinflächigen nordwestlichen Waldreste wurde, da dort keine Zählungen durchgeführt wurden, die gleiche Dichte wie in mit Waldresten durchsetzten Plantagen angenommen).

Saturday. They seem to move into plantation areas for food, because the fruits and seeds of cultivated plants and plants of disturbed habitats make up a considerable proportion of their diet (see below). The distances between the remotest places in the forests of 'Eua and plantations or disturbed habitats do not exceed 2 km, thus most of the Red Shining Parrots on the island may frequent both forests and plantations.
The quantitative data on parrot densities are summarised in table 1. The minimum number of parrots per km² in the densest populated habitats, e.g. most types of

forest, was 32; or one pair per 6.25 ha (habitats 2-4 in table I). Provided that all parrots breed in forests (RINKE in press), there are 40 individuals per km² in 19,4 km² of forest habitat, or one pair on 5 ha.

Table 1. Density estimates of Red Shining Parrots on 'Eua.
Tabelle 1. Dichteschätzungen der Pompadoursittiche auf 'Eua.

transect location	transect length L (km)	detection range E (m)	parrots counted n	area of habitat on 'Eua (km²)	total number of parrots per habitat
Upper plateau forest (north)					
Mar 83	2.6	250	16		
Apr 84	2.6	250	13	2.4	47- 56
Eastern forests (Lokupo) (a)					
Apr 83	2.2	250	18		
Apr 84	2.2	250	24		
(Telea E Hiva) (a)					
Apr 83	5.3	250	68		
Jun 84	1.3	250	13	13.7	436- 695
Coastal forest (southwest)					
Jan 84	3.0	250	27		
Apr 84	4.2	250	35	3.3	108- 118
Plantations (upper plateau)					
Jan 84	2.7	800	22		
Feb 84	4.1	800	27	22.8	182- 228
(a) see figure 3.			total:	42.2	773-1097

There are no density estimates of *Prosopeia* parrots in the literature. In the Nausori highlands of Viti Levu, Fiji, single or groups of 2 to 5 individuals of *P. personata* were sighted up to 53 times a day; the parrots were among the 5 most common species in that region (BROWN & CHILD 1975). Two population estimates of birds which in several aspects (size, food, etc.) may be comparable to Red Shining Parrots have been carried out in central Polynesia. In American Samoa, a total of 58100 Pacific Pigeons (*Ducula pacifica* was calculated for 100.46 km² of suitable habitats (AMERSON et al. 1982); that is 578 individuals per km². *D. pacifica* is, like the Red Shining Parrot, a forest-dwelling and frugivorous species (weight about 1/3 higher than the parrot). The density of the Tooth-billed Pigeon *Didunculus strigirostris* in Western Samoa was estimated at 2-3 individuals per km². The feeding behaviour of this species resembles that of *Prosopeia* parrots; it weighs between 270 and 440 g (BEICHLE 1987).

3.2 Food and feeding behaviour

Red Shining Parrots were recorded feeding on the fruits and seeds of 31 species of plants. *Myristica hypargyraea* is the most important food plant for 6 months of the year and, in total, during the whole year. The next 5 species (tab. 2) are very prolific during their fruiting seasons, and together with the fruits of *M. hypargyraea* they form the staple of the diet of Red Shining Parrots during the first 8 months of the year (Fig. 2) constituting 70.8% of the feeding birds and 60.8% of all observations. The proportion of minor food plants increases from September till December with only *Malisia* sp. being prominent besides *Myristica.*

Table 2. List of food plants of Red Shining Parrots on 'Eua, listed in order of decreasing percentage of total food.
Tabelle 2. Liste der Nahrungspflanzen

Myristica hypargyraea (Myristicaceae)	LT	Fo
Psidium guajava ** (Myrtaceae)	B - ST	dH
Inocarpus fagiferus * (Caesalpiniaceae)	LT	dH
Calophyllum neo-ebudicum (Guttiferae)	LT	Fo
Rhus taitensis (Anacardiaceae)	LT	dH; Fo
Elattostachys falcata (Sapindaceae)	LT	Fo
Carica papaya ** (Caricaceae)	ST	dH
Malisia sp. (Myrsinaceae)	WV	Fo
Pleigynium timoriense (Anacardiaceae)	LT	Fo
Melodinus vitiense (Apocynaceae)	WV	Fo
Hedycarya dorstenioides (Monomiaceae)	ST	Fo
Macaranga harveyana (Euphorbiaceae)	ST	dH
Mangifera indica ** (Anacardiaceae)	LT	dH
Faradaya amicorum (Verbenaceae)	WV	Fo
Bischofia javanica * (Euphorbiaceae)	LT	dH
Passiflora subpeltata ** and	HV	dH
P. maliformis ** (Passifloraceae)	WV	dH; Fo
Canarium harveyi * (Burseraceae)	LT	dH
Dysoxylum forsteri and	LT	Fo
D. tongense (Meliaceae)	LT	Fo
Garcinia myrticifolia (Guttiferae)	ST - LT	Fo
Vavaea amicorum Meliaceae)	B - ST	dH; Fo
Zea mays ** (Gramineae)	–	dH
Diospyros samoensis (Ebenaceae)	ST	Fo
Terminalia catappa * (Combretaceae)	LT	dH
Aleurites moluccana * (Euphorbiaceae)	ST- LT	dH
Alyxia bracteolosa (Apocynaceae)	WV	Fo
Argusia argenta (Boraginaceae)	ST	dH
Neisosperma oppositifolia (Apocynaceae)	LT	Fo
Alphitonia ziziphoides (Rhamnaceae)	LT	Fo
Burckella richii (Sapotaceae)	LT	dH

* aboriginal introduction prior to European contact; ** introduced after first European contact (cf. YUNCKER 1959); LT = large tree; ST = small tree; B = bush; WV = woody vine; HV = herbaceous vine; Fo = forest; dH = disturbed habitats.

The adult birds which were kept in aviaries seemed to be familiar with the fruits of *Solanum verbascifolium***, *Capsicum frutescens* **, *Ficus tinctoria, F. scabra* and *F. obliqua*, which they accepted immediately. In addition, juveniles took the fruits of *Micromelum minutum, Santalum yasi, Grewia crenata* and *Momordica charantia***.

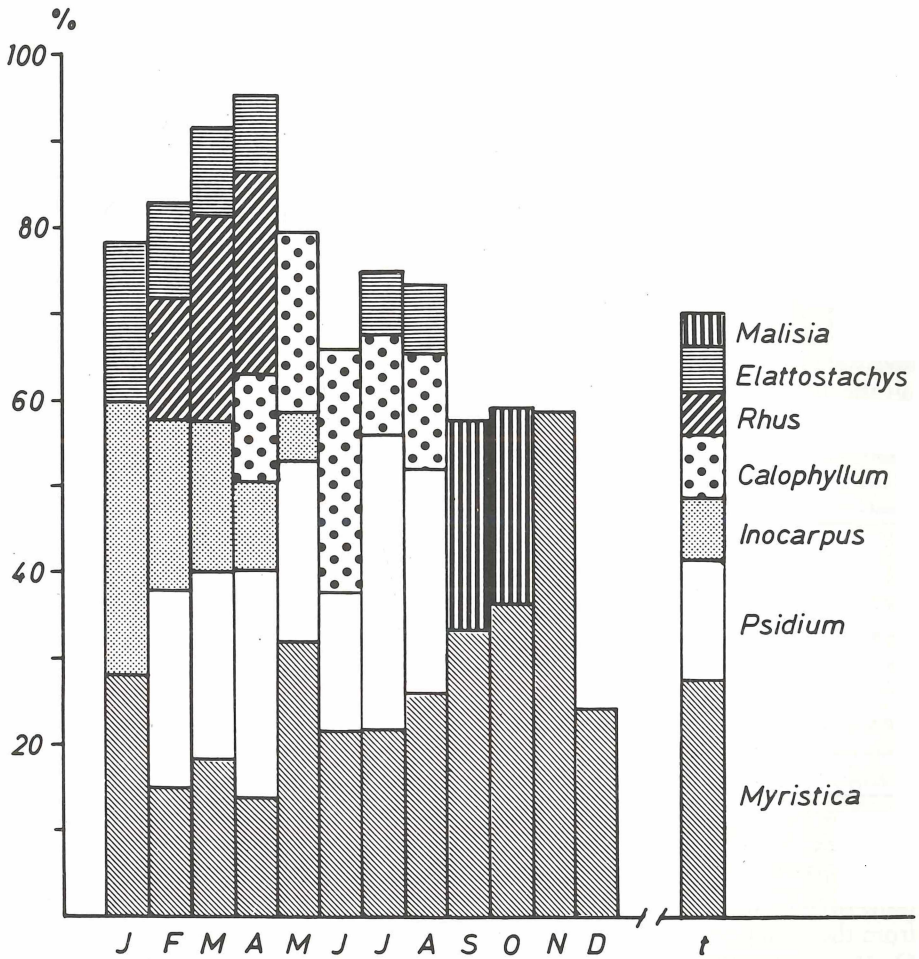

Fig. 2. Seasonal variation in the use of the seven main food plants (Numbers of birds observed during the months which were represented only once during the course of the study, were duplicated for the calculation of total [t] percentages).
Abb. 2. Saisonale Verteilung des Anteils der sieben wichtigsten Nahrungspflanzen (Um die auf das gesamte Jahr bezogenen Anteile [t] berechnen zu können, wurden die Zahlen der Beobachtungen für die Monate, die während der Freilandarbeit nur einmal vorkamen, verdoppelt).

In Fiji, *Prosopeia* species are reported to feed on corn, bananas, pawpaws, mangoes and green coconuts (LAYARD 1875, 1876a; WOOD 1923; WOOD & WETMORE 1926; BLACKBURN 1971; HOLYOAK 1979). Very few observations of non-cultivated fruits have been made, and these are mainly anecdotal (LAYARD 1876a; REICHENOW 1891; WOOD 1923; CLUNIE 1984). However, HOLYOAK (1979) saw *P. personata*, which is the ecological counterpart of *P. tabuensis* on Viti Levu, feeding on the fruits of *Inocarpus* and *P. tabuensis taviuniensis* on small wild bananas (Musaceae); PEALE (in FINSCH & HARTLAUB 1867) observed parrots taking the fruits of mangroves; and the crops of shot birds contained remains of wild figs (WOOD & WETMORE 1926).

CLUNIE (pers. comm.) lists the following species being part of the diet of *Prosopeia* parrots (see table 2 for explantation of asterics): Fruits of *Syzyqium malaccense** and other species of the genus, of different *Ficus* and *Dysoxylum* species, of the Solanaceae *Capsicum frutescens* ** and *Solanum torvum* **, of *Pometia pinnata* **, *Inocarpus fagiferus**, *Mangifera indica* **, *Psidium guajava* ** and *P. cattleianum* **; seeds from the pods of *Erythrina variegata* and *Spathodea campanulata* **; fruits and flowers of *Musa* spp. * and other Musaceae; young branch shoots of the mangroves *Rhizophora* spp. and *Bruguiera* spec.; and the fleshy leaf bases of *Freycinetia* spp.. He concludes: „There are many more species on which *Prosopeia* parrots feed — the above are only a few". In addition, WATLING (pers. comm.) observed parrots feeding on the fruits of *Dysoxylum richii* and *D. seemanni*, *Myristica* sp., *Dracontomelon vitiense*, *Spondias dulcis**, and *Aleurites moluccana**. On Gau, he saw *Prosopeia tabuensis* feeding on young cassava *Manihot esculenta* shoots on the ground.

With the exception of *Spathodea campanulata*, *Solanum torvum*, and *Dracontomelon vitiense*, all species (or geographical representatives) listed by CLUNIE and WATLING also occur on 'Eua. They probably are part of the diet of the 'Eua population of *P. tabuensis*, which in total includes more than 10 % of the higher plant species of the island.

Feeding on insects or insect larvae has been assumed (HOLYOAK 1979; CLUNIE 1984); and two observations of Red Shining Parrots stripping bark from dead trees may support these assumptions. Birds in captivity fed on dead locusts, stick insects, butterflies, skinks and geckos, the latter being very common under the bark of dead trees (sic!).

In forests, parrots mainly feed in the canopy. 21 out of 31 species of food plants are large trees or high-climbing woody vines, and most of these are growing in forests. In plantations and disturbed habitats, however, they may even descend to the ground to take copra and fallen guavas (or cassava shoots, see above), although adult birds tried to avoid setting foot on the ground when they picked up pieces of food from the aviary floor.

On sunny days, feeding occurred mainly in the early morning and in the late afternoon. In captive birds, activity was much reduced between 11.30 a.m. and 2.00 p.m., only juvenile birds occasionally fed. This activity pattern was less rigid on cloudy and rainy days; captive parrots did not take any food in heavy rainfall, even when these lasted for many hours.

Fruits were often carried to large branches and eaten there; flying birds were occasionally seen carrying fruits as large as guavas in their beaks. 7 out of 8 aviary birds took food with their right feet, one female was left-handed, sometimes using her right foot, too.

3.3 Interspecific relations

5 out of 10 species of tree-dwelling birds on 'Eua are frugivorous, i.e. the Pacific Pigeon, the Many-coloured Fruit-dove *(Ptilinopus perousii)*, the Crimson-crowned Fruit-dove *(P. porphyraceus)*, the Red Shining Parrot and the Polynesian Starling *(Aplonis tabuensis)*. In addition, fruits form part of the diet of the Polynesian Triller *(Lalage maculosa)* and the European Starling *(Sturnus vulgaris)*. The overlap in the diet of the small species and the parrot is slight, among others the fruit of *Ficus* species, *Vavaea, Bischofia* and *Alphitonia* are taken by doves, trillers and starlings, the latter also feed on pawpaws and guavas (Rinke 1987a). The Pacific pigeon feeds on a variety of fruits with a diameter of approx. 2 to 3.5 cm. Many of the fruits taken by the parrots are within this range of size. In 16 out of 27 observations, the species was feeding on the fruits of *Myristica*, those of *Pleigynium* and *Calophyllum* were also taken (Rinke 1987a). While pigeons only swallow whole fruits, flying foxes *(Pteropus tonganus)*, according to Tongans, take fruits of all sizes; and hence they may be the most serious competitors for food to *Prosopeia*. Densities of parrots, pigeons and fruit-bats, however, seem to be considerably below the capacity, the island could carry, and so abundance of food is not limiting population numbers of these species (Rinke 1987b). Besides Red Shining Parrots, Barn Owls *(Tyto alba)*, White-collared Kingfishers *(Halcyon chloris)*, Polynesian and European Starlings, and, occasionally, tropic-birds *(Phaeton lepturus)* breed in hollow trees. One nest site, occupied by parrots in 1983, was used Barn Owls in 1984. But competition for breeding sites is certainly very slight, because starlings and kingfishers use smaller holes due to their size, while owls and tropic-birds are not adept at negotiating long descents from the entrance to the nesting chamber. In parrot nest sites, these generally exceeded 1 metre (Rinke in press).

Besides man, who takes both adult and juvenile parrots from the wild (see below), Barn Owls may, probably rarely, prey on adult birds. One attack of an owl on a pair of parrots close to their nest site was observed, but the result of this attack was not known due to the darkness. Nestlings may be taken by feral cats and Black Rats *(Rattus rattus)*, but no such incidents were positively identified. Fully feathered nestlings are frequently taken by Tongans for pets, and as a result of this practise, not one of 15 monitored nests fledged young (Rinke in press).

Due to the depauperate fauna of 'Eua, the web of interspecific relations is of low complexity, with man playing the most important role.

4. Historical reflections: changes in population numbers and ecology in the course of time

> »In our work we are more or less obliged to adopt an historical perspective. We hope to emphasize that ist would be wise for ecologists to do so as well«. (G. K. PREGILL & S. L. OLSON 1981; p. 93)

4.1 Colonisation and the pre-European period

As suggested by LAYARD (1876b), and later supported by AMADON (1942), the Red Shining Parrot was introduced to the Tongan islands of Tongatapu and 'Eua prior to the first European contact (discussion in RINKE, in prep.). It was collected by FORSTER during COOK's first visit on 'Eua in 1773 (HOARSE 1982). Thus the population of 'Eua has existed there for more than 200 years, and has passed through all stages of population development after colonisation, e.g. the founder population, a phase of exponential population growth, the achievement and maintenance of a stable population size (cf. MAYR 1963, MACARTHUR & WILSON 1967).

When introduced into 'Eua, the parrots were confronted with an environment similar to that on the smaller Fiji islands (Taveuni, Koro, Gau and Kadavu), where *Prosopeia tabuensis* also occurs, with the flora and fauna being very poor in species, but most of the genera present on these Fiji islands having representatives on 'Eua (YUNCKER 1959). There is almost no evidence of a reduced diet in 'Eua Red Shining Parrots based on CLUNIE's and WATLING's observations of feeding *Prosopeia* parrots in Fiji.

Population growth may have been facilitated by the absence of diurnal raptors from 'Eua, of which 3 species are present in Fiji, e.g. the Peregrine Falcon *(Falco peregrinus),* the Swamp Harrier *(Circus approximans),* and the Fiji Goshawk *(Accipiter rufitorques),* and all of these may prey on parrots (CLUNIE 1972, 1984, pers. comm.). Prior to the first European contact, the Pacific Boa *(Candoia bibronii)* was the only non-human predator of nestlings in Fiji; this reptile is also absent from Tonga.

Potential food competitors of *Prosopeia* parrots in Fiji include Peales Pigeon *(Ducula latrans),* the White-throated Pigeon *(Columba vitiensis),* and three species of fruit-bats (i.e. *Pteropus samoensis, Pteralopex acrodonta* and *Notopteris macdonaldi),* none of which occur in Tonga. On the other hand, there were no additional species to those mentioned earlier in this paper which could interact with the introduced parrots. Hence the prerequisits for a growing and thriving population were favourable.

A period of large-scale habitat destruction and species extermination accompanied early Polynesian settlement in some islands, for example Hawai'i (OLSON & JAMES 1982, 1984), Mangaia (STEADMAN 1985), Lakeba (BEST 1984), New Caledonia (OLSON, pers. comm.), and New Zealand (ANDERSON 1984, CASSELS 1984, TROTTER & MCCULLOCH 1984), and led to the conclusion that many islands in the Pacific suffered severe faunal losses in prehistoric times (OLSON & JAMES 1982, 1984). In

Tonga, this »wholesale extinction by man before Western contact« (Olson & James 1982) has either never taken place (although evidence is increasing to the contrary; Spennemann, pers. comm.), because the early settlements were restricted to the coast line (Poulson 1977) or has since long turned into a period of equilibrium between man and his natural environment. In 1775, 25000 to 30000 people inhabited the Tonga islands (Maude 1965), between 1000 and 1500 lived on 'Eua (cf. Crane 1980). These were probably concentrated along the western coast (cf. Poulson 1977) where at present the villages lie, and where archaeological findings have been made during my stay. About 80% of the island was forested; plantations have been heavily interspersed with forest remnants and regrowth as a result of usual shifting cultivation. Based on present population densities (40 individuals per km^2), a minimum number of 3000 Red Shining Parrots may have lived on 'Eua.

4.2 The period since Cook's visit

Conditions have changed dramatically after the first Europeans visited the Tonga islands. While Tasman planted only shaddocks *Citrus maximus* during his visit in 1642, in 1773, Cook introduced a variety of cultivated plants and domestic animals (Langdon 1977). Intentional and accidental introductions occurred since that times and still occur at present. In the early 1800's, white settlers introduced guavas, pawpaws, mangoes, corn and other cultivated plants which formed additional food resources for the parrots. In the present study, about 20% of feeding birds were seen taking the fruits or seeds of plants which were introduced within the last 200 years, with guavas and pawpaws being important food plants.

The major adverse affects of the post-European contact era was the introduction of domestic cats and Black Rats as potential nest predators, and the beginning of large-scale habitat destruction. Despite a decline of the human population in Tonga due to civil wars and famines (in 1891 about 700 people lived on the island; cf. Crane 1980), the initial period of great change on 'Eua commenced in the second half of the 19th century, when up to 15000 sheep were kept (Layard 1876b), and white settlers established the first intensively worked plantations. The sheep did not survive, but the extensive areas of grass and low guava bush on the upper plateau of the northern half of 'Eua originated in the sheep pasture land.

A population decline of the Red Shining Parrot on 'Eua probably started in the late 19th century, but it became alarming after 1940, when the human population increased rapidly from approx. 1500 in 1940 to 5000 in 1980; with 1300 inhabitants of Niuafo'ou having been evacuated to 'Eua in 1946 (Yuncker 1959, Crane 1980). Farming techniques changed: the proportion of fallow land decreased, and the period of a full cycle of growing and recuperation fell from more than ten years in the old Polynesian culture to about 3 years in 1977 (Crane 1980). Forests were cleared to establish plantations and for timber. In 1968, forests covered an area of about 30 km^2; in 1983/84 about 22 km^2 were left (see fig. 3).

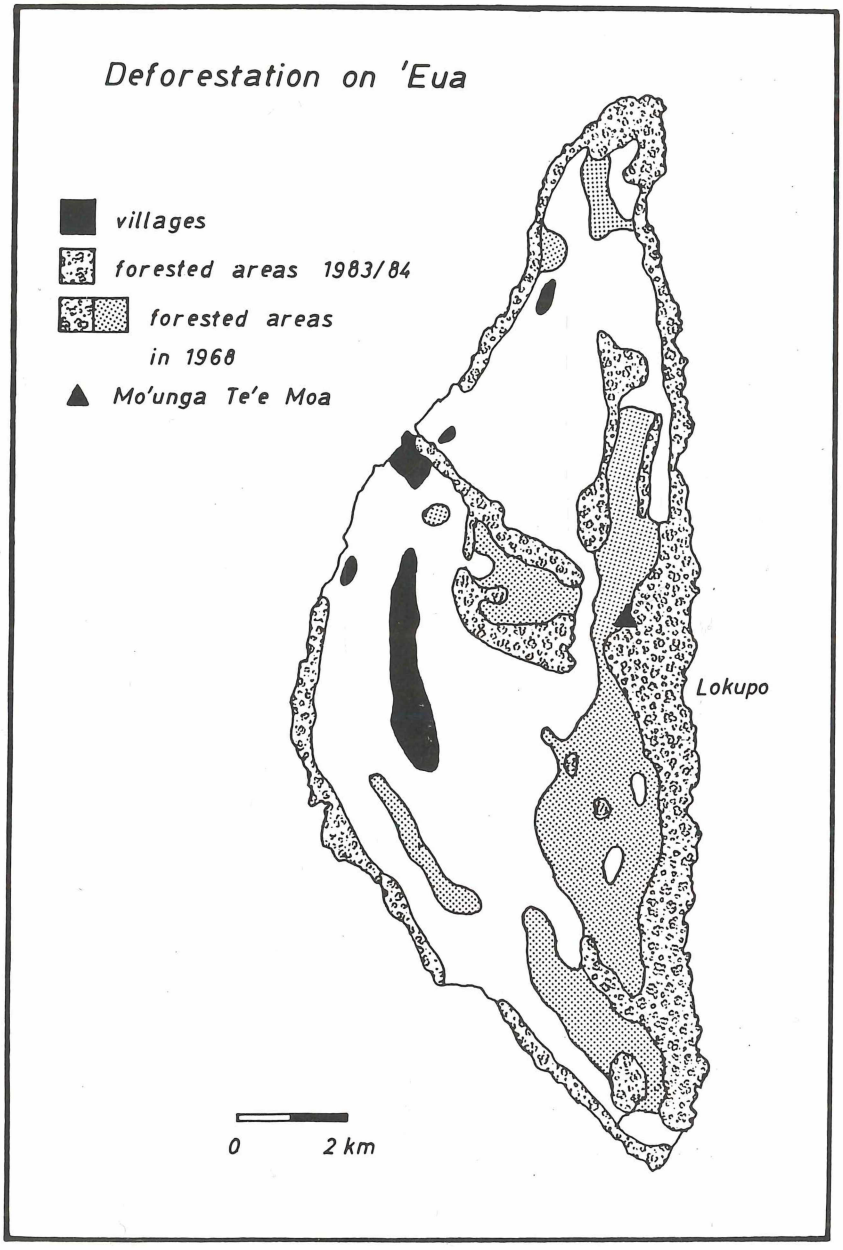

Fig. 3. Changes in forest cover on 'Eua within a period of 15 years (1968 to 1983).
Abb. 3. Abnahme des Waldbestandes auf 'Eua zwischen 1968 und 1983).

4.3 Outlook

Although the human population on 'Eua seems to be stable at present because of the emigration of young people to Tongatapu (Crane 1980), the demands for food, cash crops and timber of a growing total Tongan population are increasing. The exploitation of the forests on 'Eua will continue, as the island is one of the last extensive timber sources of the Kingdom. Afforestation with exotic trees does not provide suitable habitat for many indigenous birds (cf. Gorman 1979). Forest remnants in plantations and secondary habitats will disappear, but parts of the island (about 8 to 10 km^2) will probably remain uncultivated due to access difficulties. These, however, may not prevent man from collecting parrot nestlings in these refuges. The population of Red Shining Parrots has probably declined to about 25% of its estimated number in the pre-European era (or even less since only minimum numbers can be given). There is evidence of a further decline to less than 400 birds (based on individuals per km^2 found in this study), and this number may be critically low for the parrot's long-term survival on 'Eua. The annual production of hatchlings may not suffice both to maintain a viable population of parrots and to satisfy the demands of the Tongan people for young birds. If young birds are continously removed, the population structure will soon show an overload in the upper age classes. The sudden breakdown of some Curlew *(Numenius arquata)* populations in northwestern Germany may have resulted from such a phenomenon, where considerable population declines have not been observed before (Sossinka, pers. comm.). The importance of preserving an introduced population of birds will always be a controversial subject. The populations of Red Shining Parrots on some Fiji islands are still thriving (Holyoak 1979, Watling 1985), but there is mounting habitat destruction, and their long-term prospects are poor. Therefore every effort should be made to guarantee the survival of each population, and to ensure the continued coexistence of man and parrots in a dramatically changing environment.
As already indicated Red Shining Parrots are fairly versatile concerning habitat requirements and food. If the hunting pressure were reduced, and appropriate breeding sites in plantation areas were provided and protected, the population size could be increased. The problem is that parrots are considered a nuisance to crops such as bananas and corn. This study, however, shows that these plants form a negligible portion of the parrots' diet. Nevertheless, there is an example of the coexistence of man and a species feeding on cultivated fruits in Tongatapu, where a protected colony of about 5000 fruit-bats lives in an environment, where wild fruit trees have become very scarce.

Another possible measure to preserve the parrots in Tonga could be to introduce Red Shining Parrots on an island with a low human population, of which Tofua seems to be most suitable. There is little habitat modification, and the flora is similar to that on 'Eua, with the main food plants of the parrots being present (Yuncker 1959). Besides its conservational value, an experiment of this kind would help to understand the process of island colonisation and the subsequent phases of population development if carefully monitored.

Acknowledgements: The study on 'Eua and the subsequent evaluation of data were financially supported by the Deutscher Akademischer Austausch-Dienst (DAAD) and the Studienstiftung des Deutschen Volkes, both in Bonn, Fed. Rep. of Germany. I am very much indebted to the people of 'Eua, especially to Toafa Faka'Utoki and his family, and to 'Uili Takau, for making my life on their island comfortable, and for their support in every phase of my work. I am grateful to Dr. D. Watling, Suva/Fiji, and to W. Dressen, H. Hötker, Dr. K. Immelmann and Dr. R. Sossinka, University of Bielefeld, for their critical comments on this paper.

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