

A FIELD STUDY OF THE RED JUNGLE FOWL IN NORTH-CENTRAL INDIA

NICHOLAS E. COLLIAS and ELSIE C. COLLIAS

The purpose of this investigation was to observe the behavior of the Red Jungle Fowl (*Gallus gallus*) in its natural habitat. Such an attempt should give some perspective to the very numerous studies that have been done on the behavior of chickens by describing the natural conditions under which this behavior evolved. As deduced by Darwin (1887) many years ago and confirmed by more recent studies (Kimball, 1954; Wood-Gush, 1959), the Red Jungle Fowl is the ancestor of virtually all domestic breeds of chickens, although Hutt (1949) has interjected a note of caution against complete acceptance of the monophyletic theory. The plumage pattern in the Red Jungle Fowl is closely approximated by that of such breeds of domestic fowl as Brown Leghorn and Black-breasted Red Game (Hutt, 1949; Kimball, 1954). A study of the ecology and behavior of the Red Jungle Fowl should therefore also be of value in helping to explain the origin of domestication, and comparison of the wild bird with its conspecific domesticated descendants should throw some light on the effects of domestication.

The classical accounts by Beebe (1922, 1926) have long been the definitive description of the behavior of the Red Jungle Fowl in nature. More recently, Johnson (1963) has reported some observations on the behavior of this species in the forests of west-central Thailand. Delacour (1951) has reviewed the taxonomy and distribution of the various races of jungle fowl. We wished to extend these studies where possible in an attempt to gain a more complete acquaintance with the life of this important bird. A brief abstract of part of our study in India as well as in Southeast Asia has been published (Collias, Collias, and Saichuae, 1964).

GENERAL AREA OF THE STUDY

Our observations were made during the main breeding season of the Red Jungle Fowl in April-June 1963, in north-central India in the Siwalik Hills just south of Dehra Dun and about 100 miles (161 km) north-northeast of New Delhi at about 30° N lat, 78° E long (fig. 1). A general description of the ecology of this area is in Sahai (1954), and the flora is described by Gupta (1928). The Siwalik Hills here range from about 1400 to 3100 feet (427-946 m) and consist of sandstone and conglomerates, interbedded with bands of often shaley clay. Much of the area is characterized as "bhabar," *i.e.*, a gently sloping tract below the main Himalayans comprised of gravel and boulder deposits. Absence or scarcity of surface water, particularly in the dry season, is characteristic of streams or "raos" (stony watercourses dry during most of the year) because of the great depth of the rock deposits into which the water sinks. Frosts are common in the Siwaliks at the end of December and early January. The temperature rises rapidly from March through the first half of June, when thunderstorms may occur.

The monsoon begins about the middle of June with heaviest rainfall in July and August. The summer rains stop by the end of September, and the period from October to December is characterized by clear skies, great temperature range, and heavy dew at night. There is some rain again during the winter, followed by a dry season during the spring months, when forest fires are likely to occur, particularly on the drier slopes of the Siwaliks in the Saharanpur Forest Division. These fires are

apparently started by some of the people at times in order to improve the bhabar grass crop. Grazing pressure in forests is heavy near villages.

The north-east slopes of the Siwaliks near the town of Dehra Dun, in the Dehra Dun Forest Division, are far more humid and the vegetational cover more luxuriant than is the case with the south-west slopes near the town of Saharanpur in the Saharanpur Forest Division. For a variety of reasons, such as the greater visibility of jungle fowl in the drier and more sparsely vegetated area, we did most of our work in the Saharanpur Forest Division.

The vegetational cover in these two forest divisions consists especially of sal tree (*Shorea robusta*) forest, scrub, and miscellaneous trees such as sissu (*Dahlbergia sissu*) and khair (*Acacia catechu*) with some bamboo. In the more hilly portions there are fewer sal trees and apparently fewer jungle fowl.

METHODS OF STUDY

We located jungle fowl by cruising the roads and especially by listening for the dawn crowing. Counts of crowing made throughout the day enabled us to trace the movements of the birds to some degree, as well as to gain some idea of differences in local abundance. Direct observations, with the aid of binoculars, were made of various aspects of the life of jungle fowl by careful stalking on foot, by observation from a car along the roads, from elephant-back in the jungle away from roads, from machans (platforms in trees), from camouflaged hides near the ground, and by using a telescope focussed on a water hole during the dry season. Local guides were indispensable and also provided useful information concerning possible foods or enemies of jungle fowl. Certain plants and insects of seeming significance to jungle fowl were identified for us by specialists of the Forest Research Institute at Dehra Dun.

During the last month of the study we obtained a collecting and banding permit, and managed to net and color-band a dozen jungle fowl. But these birds were not seen again. Photography (still and motion picture) was used quite extensively in all phases of the work. We made a short film "Jungle Fowl in India and Ceylon" (Collias and Collias, 1965) that is being distributed through the University of California at Berkeley and the Pennsylvania State University. Tape recordings were made in the field of the crowing and certain other vocalizations of jungle fowl.

DISTRIBUTION, HABITAT AND LOCAL DENSITY

According to Delacour (1951), the Red Jungle Fowl (*Gallus gallus*) ranges from northeast and central India, extreme southern China, and Southeast Asia generally to Sumatra, Java, and Bali. It has been subsequently introduced in a great many other places. The Indian race *murghi*, with which we are here concerned, ranges from northeast and central India to western Burma. To the north its distribution is limited by the Himalayan Mountain Range. Baker (1928) states that this race is not often found above 5000-feet (1524 m) elevation, and in general its range coincides with that of the sal tree.

The term jungle is so vague as to be of little aid as an indication of the specific nature of jungle fowl habitat. The place where we observed the birds to be most concentrated was along an old, little-used road closed to motor cars that was located about a quarter of a mile northwest of the Dholkhand Forest Rest House or dak bungalow. The vegetational cover consisted of an upper story of sal trees, reaching 60 to 80 feet (18-24 m) in height with scattered large banyan trees here and there, of a middle story of miscellaneous small trees (*Ehretia laevis*, *Mallotus philippensis*,

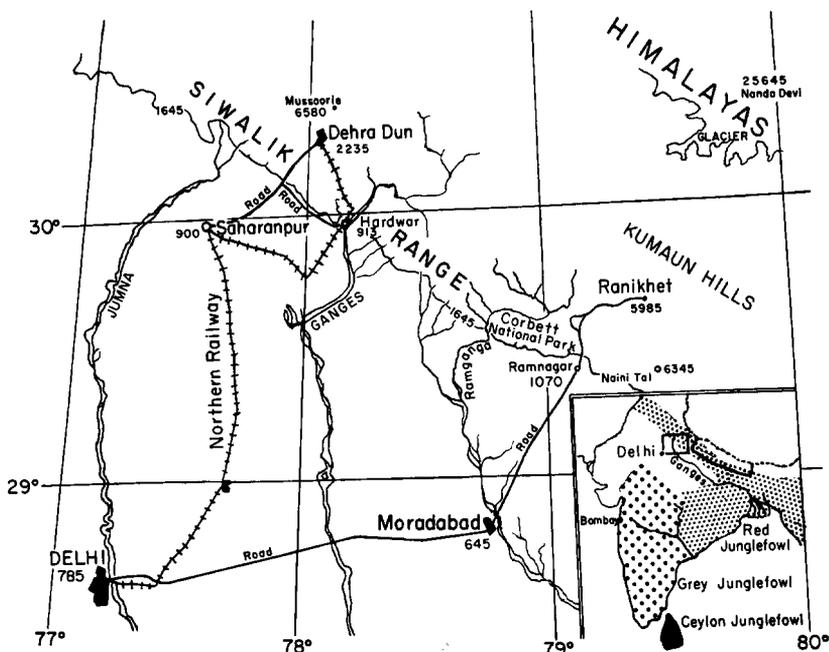


Figure 1. Map of the general location of that part of the Siwalik Range where the investigation was conducted. The inset to the lower right shows the location of the more detailed map, and also the geographic ranges (from Delacour, 1951) of the species of jungle fowl studied. Elevations are shown in feet, the customary notation in India. The 1645-foot (500 meters) contour line of the Siwalik Hills is indicated.

Zizyphus jujuba, and others), and an understory of tall herbs especially *Adhatoda vasica* and in places tall bunchgrass (*Saccharum arundinaceum*). The undergrowth was sufficiently spaced so that jungle fowl could readily walk about among the plants.

Wild elephants were common in this area, and therefore it was avoided by the local people. In this same general area three tigers had been shot within one hour by a hunting party not long before our visit, and other big game animals, particularly leopard and cheetal (spotted deer), were common. The abundance of cheetal and langur, both favorite prey of the leopard, possibly served to reduce predation on jungle fowl by leopards. However, the extent and importance of leopard predation on jungle fowl seems to be unknown.

The relatively high density of jungle fowl in this area was probably related to the food supply. Termite mounds were common, although no more so than in other places where jungle fowl were not so common. The small fruiting tree *Ehretia laevis* was abundant here compared with other localities seen, and jungle fowl were seen perching in the branches and eating its small red fruits. Banyan trees (*Ficus bengalensis*) and other fruit trees also occurred. Abundant elephant droppings may have provided some source of food for jungle fowl in the form of various dung-inhabiting insects.

Good brood-rearing cover in the form of patches of a tall bunchgrass known as sarkanda grass (*Saccharum arundinaceum*) was another reason for the abundance of jungle fowl in the area. Most of the broods we saw were concentrated in or near

patches of this grass, the tall, spreading leaves of which provided good concealment for partly grown chicks. The relatively open spaces among the patches of bunchgrass allowed for easy lanes of travel, since jungle fowl prefer to do most of their traveling by walking or running on the ground. Three different water holes in Dholkhand Rao, which bordered the area to the south and southeast, were present within 100–200 yards (91–183 m) of this area.

The habitat relations and daily routine of jungle fowl tend to center about their roosts, which are unchanged only so long as the birds are not disturbed. We often found it difficult to locate birds and roosts by the dawn crowing because the birds shifted to another roosting spot after we had discovered and disturbed them. To avoid this problem we located and mapped with aid of a compass all the nearby roosts from the roof of the Dholkhand Forest Rest House by the sound of crowing only, and we did not attempt to approach directly any of these roosts until the last month of the study. The sites of the roosts thus remained quite constant as checked during the first part of April, May, and June. There were four of these nearby roosts, and their distribution as determined by compass triangulation from the forest rest house (dak bungalow) is shown in figure 2. The composition of the four flocks during May or early June in terms of adult males and females, including subgrouping within each, was as follows: NE Flock, 1M + 1F, 1M; East Flock, 1M + 2 F; South Flock, 1M + 3F, 4M; and SW Flock, 1M + 3F, 3M. Nearby, along the closed road we called "junglefowl lane," the birds were most concentrated, and some of the crowing sites at dawn were separated by only about 100 yards (91 meters) or even less.

We attempted an estimate of population density of jungle fowl per acre of suitable habitat by assuming uniform spacing of roosts and taking the average distance between roosts. The most accurate estimates of distances between roosts (about 250 yards or 228 meters) and estimates of flock size (about five birds) were obtained from the flocks roosting near the Dholkhand Forest Rest House. From these data we calculated a population figure of approximately 2.5 acres (one hectare) per bird about this dak bungalow. Since the entire flock area was probably available to every bird of the flock, each individual bird actually had some 12.5 acres (5 hectares) to range over.

BREEDING SEASON OF THE RED JUNGLE FOWL IN NORTH-CENTRAL INDIA

According to Sálím Ali (1961), the nesting season of the Red Jungle Fowl in India is principally from March to May, thus coinciding with the dry season in the spring.

During the early part of April, May, and June in 1963 we counted all crowings heard from the roof of the Dholkhand Forest Rest House in the Saharanpur Forest Division during the dawn peak of crowing, starting about one-half hour before dawn and continuing for one and one-half hours until after the sun rose over the hills to the east. The greatest peak of crowing occurred in early May, and the frequency of crowing had declined by early June.

Cocks were often seen alone, especially during the period of intense competition for mates in April and May, in contrast to the hens, which were seldom by themselves (table 1). From April to June the total number of observations of cocks alone or with other cocks was 44, of cocks with hens, 41. Thus, over half the cocks seemed to have no opportunity to mate during the main part of the breeding season. In the

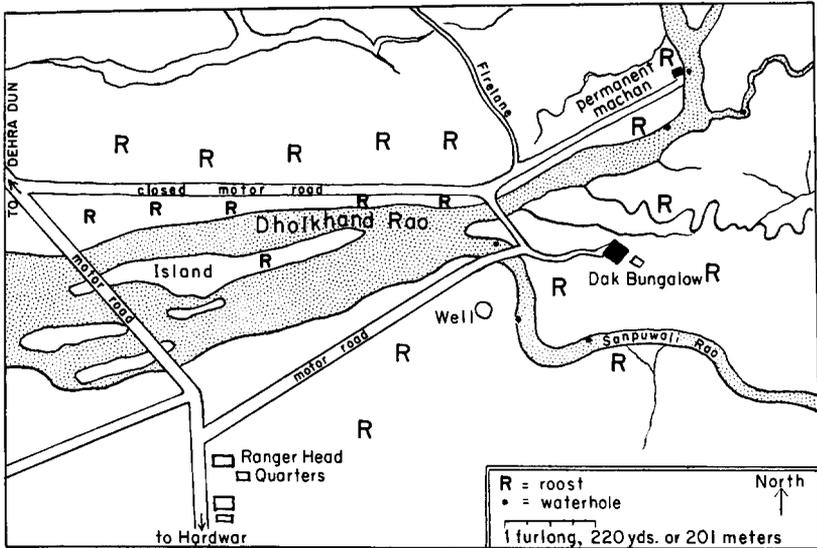


Figure 2. Map of the study area near the Dholkhand Forest Rest House (dak bungalow), showing location of Red Jungle Fowl roosting sites.

last week of June some cocks were observed to have molted their golden capes, and their necks looked more or less black.

Only two copulations were seen; these occurred in April. The first broods were seen on 8 May, and broods were common by early June when we saw 11 broods within nine days. In fact, over half of the hens seen in June had broods, including all hens that did not have a cock in immediate attendance. Most of our study area had been burned over by June, and the birds were easier to detect.

DAILY ROUTINE

The general daily routine of Red Jungle Fowl in India is briefly indicated by Baker (1928): "During the heat of the day they sleep in the forest in some tree or clump of bamboos but from dawn to about 9 a.m. and again from 3 or 4 p.m. until dusk they may be seen wandering about in the crops." We agree with this statement except that, aside from tree plantations, there was little or no cultivation in our areas of study.

The day of the Red Jungle Fowl begins with the period of dawn crowing. Such crowing reinforces the general territorial relations of the birds, helps to keep them spaced, and reinforces the dominance relations between cocks within a flock. Most of the crowing is done by the dominant cock of the flock. All the roosts seem to be announced by the dawn crowing, which provides a good method of locating the flocks. During the height of the crowing season a sharp peak comes shortly after dawn. This may be followed by a secondary peak before sunrise, which probably coincides with the birds' movement from the immediate vicinity of the roost to drink and feed (fig. 3). Relatively little crowing is heard during the day, but there is a minor peak in the evening before sunset as the birds roost.

Figure 4 shows representative graphs of crowing frequency for different days in April, May, and June of 1963. The birds tend to start crowing earlier each morning

TABLE 1
SEX RATIO OF DIFFERENT GROUPS OR SUBGROUPS OF JUNGLE FOWL SEEN IN
NORTH-CENTRAL INDIA, APRIL-JUNE 1963

Sex ratio in group Male : Female	Number of such groups			
	April	May	June	Total
0 : 1	0	1	5	6
0 : 2 to 3	0	0	4	4
1 : 0	13	18	4	35
2 to 4 : 0	0	7	2	9
1 : 1	3	6	5	14
1 : 2	7	5	2	14
1 : 3	4	2	1	7
1 : 4	1	0	0	1
2 : 2	0	1	1	1
3 : 3	0	0	1	1
Sex ratio each month	23 : 33	51 : 25	23 : 32	102 : 90

as the season progresses. The loss of the secondary peak in the morning during June coincides with the onset of the rains, so that it is no longer so necessary for the birds to visit water holes. The form of the curve on 11 April with a full moon still visible at dawn is quite similar to the curve of 5 May, which was a clear, dark night with no moon and not so cold as the night of 11 April. But the curve for 5 June, a warm cloudy dawn with some lightning, shows a fairly sharp peak in contrast to the lower, more rounded peak of crowing by the same birds a few days later at dawn of 8 June, which was clear, slightly cooler, and with a full moon.

The birds may show an increasing tendency to crow as dawn approaches, as indicated by the fact that the interval between the occasional predawn crowings as heard from the Dholkhand Forest Rest House has a tendency to decrease gradually. Thus, on 13 April from 02:30 to 05:45, the following successive intervals between crowings were recorded in minutes: 30, 15, 10, 7, 10, and 10, with dawn coming between 05:30 and 05:45. Comparable intervals on 16 April, recorded between 03:30 and 05:45, were: 30, 20, 10, 5, 20, 7, 8, 6, 3, and 3, suggesting that the tendency to crow may be subject to some systematic build-up and oscillation.

As a rule, crowings seem to come in bursts, one cock often seeming to answer and to stimulate others. Tests with play-backs of recorded crowings usually gave no clear response. However, when near a jungle cock, we at times definitely managed to attract it and stimulated it to crow back by playing recorded crowings singly in reply each time the bird crowed.

Examples of the temporal patterns of the morning and afternoon crowings from a single flock are shown in tables 2 and 3, respectively. The number of crowings were recorded at five-minute intervals during a period of 7½ hours, the more active parts of the flock's daily routine. Since subordinate cocks normally crow much less than does the dominant cock of a flock, most of the crowings recorded are believed to have come from a single bird. Furthermore, subordinate cocks during the breeding season are usually kept at some distance from the hen by the dominant cock. Therefore, if more than one cock in the flock had usually been crowing, the sounds often would have seemed to come from different directions. But they did not. A number of conclusions can be drawn from these tables: the resident and dominant cock

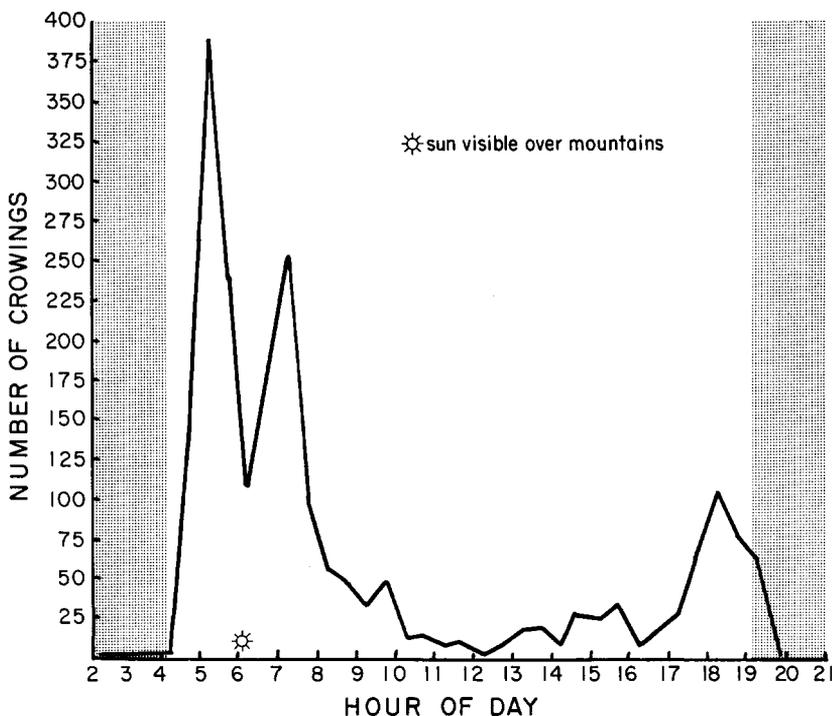


Figure 3. Typical variations in crowing frequency throughout the day. This graph is actually a composite of counts made on several successive days, 4 to 8 May. All crows within earshot of the dak bungalow at Dholkhand were counted and are here graphed at half-hour intervals. Stippled areas show darkness exclusive of civil twilight.

crows most often at dawn, near his roost, and in reply to intruding cocks coming near his territory. Evidently much of the crowing heard during the day is a result of the cock patrolling his territory. On 6 June we recorded a vocal duel at the territorial boundary (ridge of hill) between the cock whose territory was east and northeast of our dak bungalow and a cock to the southeast. These two birds crowed back and forth at each other for almost one-half hour. On the other hand, we noted that a cock disturbed by a human observer might cease crowing for some time and move silently for many yards.

During the dry season an important part of the daily routine of many jungle fowl was related to visits to water holes, although we have seen jungle fowl in a place which local woodcutters informed us was two to three miles from the nearest water. In such places jungle fowl presumably rely on succulent fruits and green leaves for their water, and perhaps also on dew. To gain an accurate idea of the time of drinking in the routine of the birds, we focussed a 35-power telescope on a water hole some 275 yards (251 m) away. Since the telescope was set up just outside the bungalow where the animals were accustomed to seeing people, and since the water hole was at such a great distance, the animals were not disturbed and no doubt continued their normal routine activities. The water hole was observed through the telescope at various times on different days. Table 4 shows the hours of the day when jungle fowl visited the water hole and drank during early May in the latter

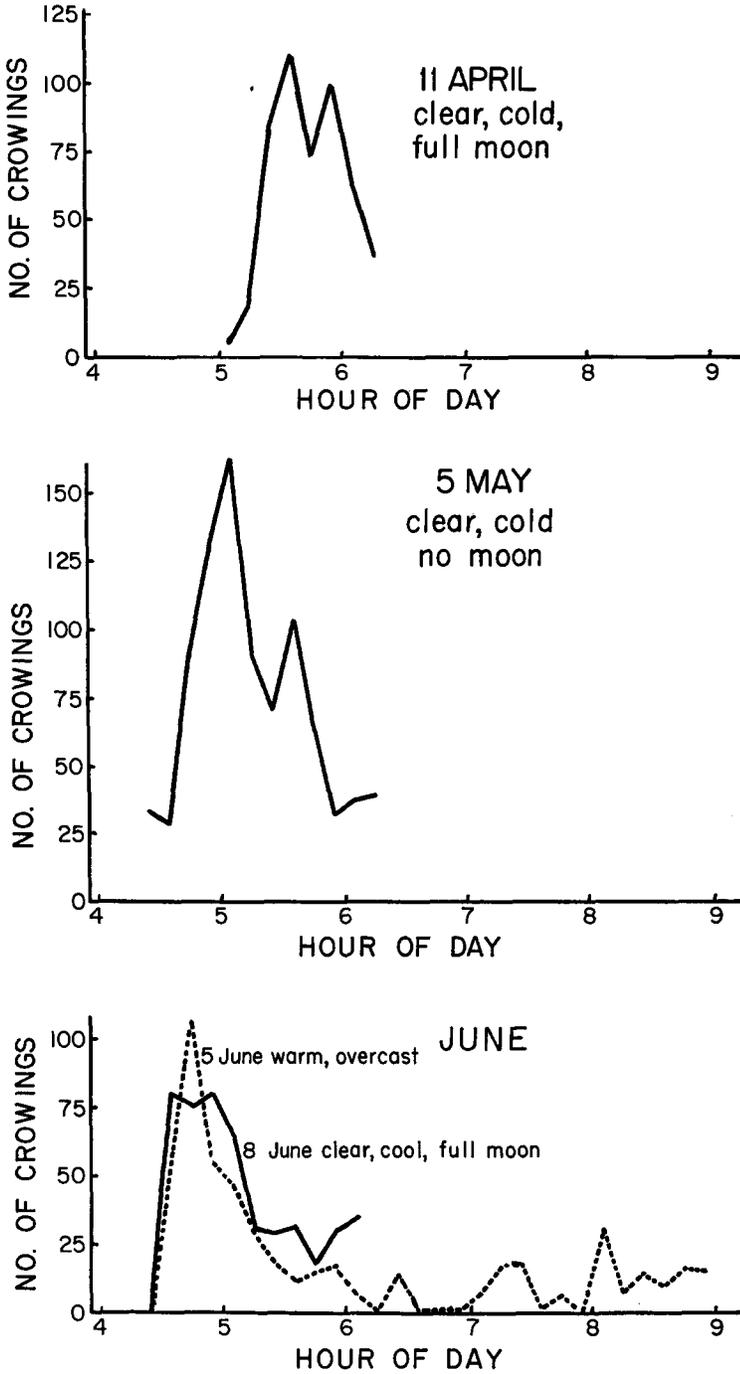


Figure 4. Typical curves of crowing frequency for the three principal months of the breeding season. All crows heard from the dak bungalow at Dholkhand were counted and are here graphed at 10-minute intervals.

TABLE 2

MORNING PATTERN OF CROWING FROM ONE FLOCK, MOSTLY BY A SINGLE COCK, TAKEN AT FIVE-MINUTE INTERVALS FROM 05:00 TO 10:00, 5 MAY 1963, NEAR DHOLKHAND FOREST REST HOUSE, SAHARANPUR FOREST DIVISION

Time	Number of crowings	Time	Number of crowings
05:00-05:05 (on roost)	7	07:20	0
		07:25	0
05:10	7	07:30	6
05:15	13	07:35	0
05:20	12	07:40	0
05:25	5	07:45	6 ^a
05:30	8	07:50	5 ^a
05:35 (leaves roost)	8	07:55	0
05:40 (to water hole)	5	08:00	0
05:45	10 ^a	08:05	17 ^b
05:50	8	08:10	14 ^b
05:55	4	08:15	4
06:00 (sunrise over hills)	3	08:20	12
06:05	0	08:25	3
06:10	8	08:30	3
06:15	6	08:35	0
06:20	7	08:40	10
06:25	9	08:40-09:45	0
06:30	7	09:50	5
06:30-07:00	0	09:55	0
07:05	2	10:00	0
07:10	4 ^a		
07:15	0		

^a Crowing in reply to approach of a neighboring cock.

^b Crows on arrival back near roost.

part of the dry season. In general, most birds came early in the morning, the earliest one being seen at 05:40, before sunrise, while the latest one to drink in the morning came at 08:28. During the hot part of the day from 09:00 to 17:00 no birds came to drink. Jungle fowl were again seen to come to drink in the evening, the first recorded one being seen at 17:20 and the last at 18:35.

Judging by the number of jungle fowl seen, composition of subgroups, and the varied directions from which the birds came and departed, the water hole served jungle fowl from more than one flock or roosting area. On arrival at the water hole the jungle fowl would show every sign of thirst, and often a bird would drink repeatedly for two or three minutes, raising its head between sips and glancing this way and that for possible danger. As many as six jungle fowl, in two groups, were seen at the water hole at one time, but generally the birds came and departed singly or in small groups. After drinking, the jungle fowl promptly walked off.

Many other species of animals, including wild elephants, cheetal, barking deer, and langur, used this particular water hole. Domestic buffalo and cattle were at times driven down the road by graziers and sometimes used this water hole. Most species caused little modification in the routine of the jungle fowl. Peafowl, kaleege pheasant, hawks, doves, tree pies, a Red-wattled Lapwing, and many smaller birds

TABLE 3

EVENING PATTERN OF CROWING FROM ONE FLOCK, MOSTLY BY A SINGLE COCK, TAKEN AT FIVE-MINUTE INTERVALS FROM 16:45 TO 19:15, 5 MAY 1963, NEAR DHOLKHAND FOREST REST HOUSE, SAHARANPUR FOREST DIVISION

Time	Number of crowings	Remarks
16:45-17:05	0	Sun still very hot
17:10	10	Crows from near water hole
17:15	0	
17:20	0	
17:25	0	
17:30	12 ^a	Cooler; back near roost
17:35	0	
17:40	0	
17:45	5 ^a	Resident moves toward intruding cock
17:45-19:00	0	Sunset at 19:00
19:05	6	
19:10	0	
19:15	4	Crows back in vicinity of roost

^a Crows in reply to approach of a neighboring cock.

also drank at the water hole. Peafowl and jungle fowl were seen to drink at almost the same time, the jungle fowl usually keeping out of the way of the larger species. We have seen peafowl chase jungle fowl from a water hole. Small herds of deer were seen to pass within 10 feet of jungle fowl at the water hole, and the birds paid little or no attention.

The jungle fowl customarily spent most of the cool, early hours of the morning feeding as they moved along. Several times we noted that cocks crowed from the roosting area for about half an hour after dawn before moving out. The earliest we ever saw a cock feeding on the ground was 15 minutes after dawn. Movements of a flock were determined by estimating the direction and location of a crowing male from a machan in which the observer was hidden. The exact time and approximate location of crowings were then plotted on a map. From time to time the birds could be seen through the screen of vegetation, which enabled the observer to ascertain the composition of the group. It will be seen from figure 5 that the flock, which included the dominant male, the hens, and the subordinate males that trailed after, moved in a generally counterclockwise direction in the morning from the roost to water, circling the machan which was placed near the roost, and returned to the vicinity of the roost to rest during the hottest part of the day. During the evening of the same day, the same observer sat in the same machan and again followed the movements of this group from the sound of the crowing. From figure 5 it may be seen that following a visit to the water hole shortly after 17:00, the birds returned to the roost area and continued on in a clockwise direction, gradually circling the machan and the hidden observer in the course of the evening feeding circuit, returning finally to the same roost for the night. Although this particular flock was not watched during the blazing heat of that day, it may be safely assumed from the behavior generally noted for jungle fowl that the birds spent most of this period of the day in relative inactivity. Figure 5 may, therefore, be taken as representative of the daily circuit of a flock of undisturbed jungle fowl. Interestingly enough, the total

TABLE 4
TIMES OF DAY WHEN JUNGLE FOWL WERE SEEN TO COME AND DRINK AT A WATER HOLE NEAR
DHOLKHAND FOREST REST HOUSE, SAHARANPUR FOREST DIVISION, INDIA, MAY, 1963

Time of day	Total hours observed	Number of jungle fowl	Jungle fowl per hour
05:30-07:00	4	5	1.3
07:00-08:00	4	2	0.5
08:00-09:00	3	6	2.0
09:00-13:00	4	0	0
13:00-17:00	4	0	0
17:00-19:00	4.5	6	1.3
Totals	23.5	19	

area covered by the movements of the birds on this day was only about 150 yards (137 m) in diameter. Early the following morning the birds were similarly watched and again followed a counterclockwise pattern over much the same area. That evening, however, they were disturbed while we were attempting to make arrangements for photography. Their crowing greatly diminished in frequency, and the birds became much more secretive and difficult to observe and shifted their roosting site elsewhere.

Figure 6 shows the extent of movements of another, smaller flock, as determined from estimated locations of crowing throughout the entire day. The territory of the dominant cock was to the northeast and was nearest to our dak bungalow. He was at times accompanied by one hen. Only one other cock, an immature one, was ever seen in the same general area. In all probability the great majority of the crowing was done by the dominant male. The extent of the area covered during the day was only about 100 yards (91 m) in diameter. The cock made one circuit in the morning, returning to the roost at noon to rest for some five hours before making a second circuit in late afternoon within a different part of the territory.

Not all cocks have such a restricted range of daily movement. Several miles away near Bam Rao one evening we watched a cock and two hens feeding in a mulberry plantation. They started for their roost at sunset, and it was remarkable to observe the speed and steady rate with which they began to walk, covering some 300 yards within 15 minutes and travelling across a branch of a ra0 to an island where they went to roost about 20 feet up in a thorny tree (*Zizyphus*) less than half an hour before dark. The cock crowed three or four times as he approached the roost to within 50 yards and only once more after he flew up into the roosting tree. The wary behavior of these birds, their speed of movement, the distance covered, the near absence of crowing on the roost, and the lateness of the hour contrasted strongly with the roosting behavior we had earlier observed in the tame population of Red Jungle Fowl that range freely over the grounds of the San Diego Zoo and where the birds often assemble directly under their roost trees well before sunset and usually fly up into the roost tree long before dark.

FEEDING BEHAVIOR

More precise information is needed on the diet of the Red Jungle Fowl at different seasons of the year in its native habitat. Bump and Bohl (1961) obtained 37 crops of this species from northern India, mostly from the six-month hunting

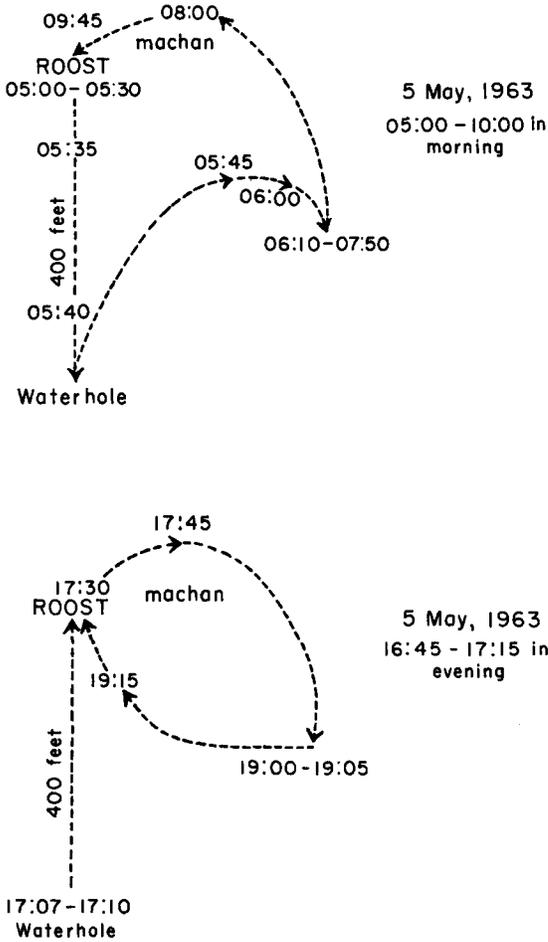


Figure 5. Pattern and extent of daily movements during the active periods of morning and evening in a flock of Red Jungle Fowl near the dak bungalow at Dholkhand. Locations of crowing birds at different times of the day were estimated by an observer seated in a machan.

season, September to February. These crops contained some 30 different kinds of seeds (e.g., of *Shorea robusta*, *Zizyphus*, *Carissa*, rice, and other grasses), insects of various orders, spiders, and snails. They state that jungle fowl in India also eat earthworms and lizards. Beebe (1926) mentions that in the crops of birds that he shot at considerable distances from cultivation he always found vegetable matter predominating, and that young shoots of bamboo and other grasses, leaves, petals, and wild seeds of all kinds are eaten.

Jungle fowl seem to eat a wide variety and a succession of fruits and seeds which become available at different seasons. We saw Red Jungle Fowl feeding on fruits of banyan (*Ficus bengalensis*) trees on the ground and on fruits up in the branches of mulberry (*Morus*) and chamro (*Ehretia laevis*) trees. Our shikari pointed out various other trees and shrubs that bore fruits and that he said jungle fowl feed on, including species of *Carissa*, *Flacourtia*, *Ficus religiosa*, *Zizyphus*, *Grewia*, *Cordia*,

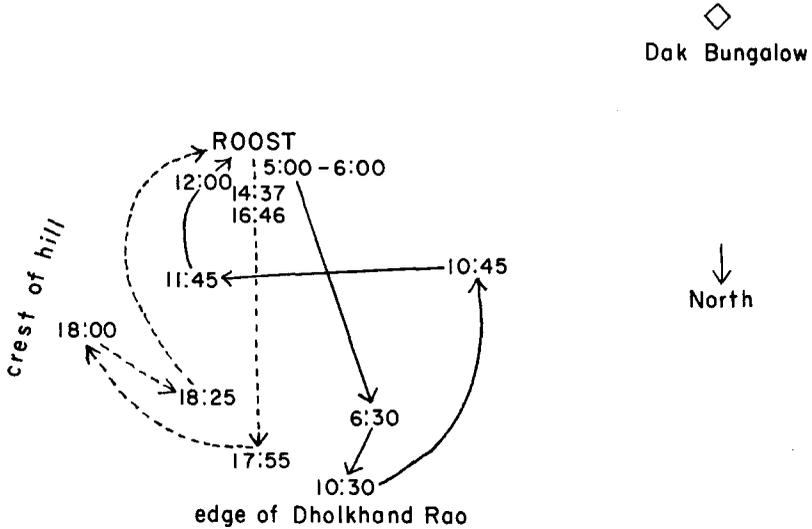


Figure 6. Pattern and extent of daily movements of a single Red Jungle Fowl cock near the Dholkhand dak bungalow. Locations of the crowing bird during the entire day were estimated from the bungalow.

and *Eugenia*. According to Holdsworth (1958) Red Jungle Fowl congregate in large numbers at thickets of ber (*Zizyphus jujuba*) bushes when the berries are ripening about November. Similarly, he notes that jungle fowl aggregate about bhansa (*Adhatoda vasica*) when the seeds ripen.

When we visited the Corbett National Park in May there was in the sal forest a heavy infestation of geometrid larvae. These caterpillars were so abundant that they were a continual nuisance to travelers in the forest, and the sound of their droppings on the dry leaves of the forest floor resembled the dripping sound of a constant and gentle rain. The Assistant Wildlife Warden of the Park, Shri N. S. Negi, informed us that these caterpillars appeared every year about the same time, and that they fed on the pollen of the sal tree and were in turn fed on by jungle fowl and other birds.

Termites are probably a general and an important seasonal food of jungle fowl. Bump and Bohl (1961) found termites in the crops of some of their jungle fowl, and a number of reliable observers told us they had observed jungle fowl eating such food during the termites' mating flights. The first termite flights appear during the premonsoon showers, and, according to P. H. Chatterji, entomologist of the Forest Research Institute at Dehra Dun, the main flights come in June and July. This is a time when there are many growing jungle fowl chicks in the forest, and termites must comprise an important part of their diet. We were informed by Chatterji that the commonest mound-building termite throughout northern India is *Odontotermes obesus*, and P. K. Sen-Sarma, also of the Forest Research Institute, identified the termites we collected near the Dholkhand Forest Rest House as belonging to this species (see also Mathur and Sen-Sarma, 1962). During the dry season these termites withdraw from the superficial portions of their mounds, and in April we found few termites in those mounds into which we broke. In contrast, during early June almost every pinnacle we broke was crowded with termites just beneath the outer

shell of the nest. Where new colonies have been recently established, the fragile tunnels are easily broken.

We often observed jungle fowl scratching for food in the leaf litter, and the presence of spots cleared of leaves is one means that hunters use to locate jungle fowl. By sifting through and under the leaf litter in June, we observed that quite a few insects were available there.

During the dry season the forest floor is often burned in many places, and the immediate effect is some shortage of food. At this time elephant, buffalo, and cattle dung, which may contain seeds and various insects, probably provides some source of food to the jungle fowl.

A species of red bug (Pyrrhocoridae) was very common crawling about on the ground throughout the forest, and we were told it was a food item of jungle fowl. However, domestic chickens to which we gave some of these bugs generally ignored them, preferring instead to eat rice which we also scattered before them.

Although some insects may be distasteful to jungle fowl, the evidence suggests that, as in the case of fruits of trees, different species of insects are available to jungle fowl at different seasons of the year. Because of their increased availability during the period of early growth of young jungle fowl, termites may be particularly important.

A peck order related to competition for food, among other things, probably exists in wild jungle fowl, similar to that which Banks (1955, 1956), Lill (1966), and we have observed in captive Red Jungle Fowl. For example, on 14 April 1963, we were observing a cock and two hens in the Saharanpur Forest Division searching for food on the ground in a mulberry plantation. One of the two hens found a good feeding spot and began pecking there repeatedly. The other hen approached four times in quick succession, and each time was driven off by short thrusts or lunges, promptly retreating in typical subordinate fashion.

Many other species of birds and mammals feed on some of the same foods in nature as does the Red Jungle Fowl, and both competitive and cooperative relationships to the food supply in the forest are therefore to be expected. For example, one of the chief characteristics of the habitat in the spot where we found jungle fowl most abundant in north-central India in April 1963 was a corresponding abundance of chamro (*Ehretia laevis*) trees in fruit. In addition to the jungle fowl, we also observed various small birds, peafowl, palm squirrels, and langurs eating the fruits of these trees. As an example of how one species might benefit from the presence of another in its feeding requirements, we have seen langurs feeding in banyan trees while underneath on the ground, jungle fowl were feeding on banyan fruits which had fallen because of the activities of the monkeys.

BREEDING BEHAVIOR

The Red Jungle Fowl cock appears often to be polygynous—at least one often sees early in the breeding season a jungle cock in company with two or more hens. Later it is more common for a single cock to be in company with but one hen (table 1), as some hens go off to nest and to incubate their eggs. Also, hens with broods were often not closely associated with any cock. Before the appearance of chicks, it was rare to see a hen alone; on the other hand in April and the first half of May we often saw single cocks or cocks in company with other males.

These discrepant sex ratios within groups emphasize the great competition for females among the males, and help account for the pugnacity for which this species

is noted. But the birds are wary, and only a few times did we observe fights between adult cocks in the forest during the breeding season. Frequently, a cock together with hens would be followed persistently at some distance by a subordinate male. Quite often the latter was a young cock with short sickles, in contrast to the long flowing sickles of the dominant male. A dominant cock tends to keep his tail more erect than does a subordinate male. An example from our field notes illustrates a typical interaction between cocks.

April 14, 17:45-15:05. We watch a cock and two hens near Bam Rao, as they feed in the open at a Mulberry tree plantation until about sunset. At 18:00 the cock suddenly mounted and copulated with one of the hens, at the same instant she crouched for him, there being no other preliminary display apparent. At 18:45 the birds started for the roost, and another male with quite long sickles appeared. At once the first male left the hens and chased the intruder which promptly ran away. The dominant male then crowed once or twice, this being the first time he had crowed since observations began over an hour ago.

Either sex may temporarily lead the way during excursions, but more often it is the male, who, furthermore, can readily attract the hens to him with a special courtship or food call given while he scratches about for some real or imaginary tidbit. We have seen a hen come running from 20 or 30 feet (6-9 m) away to a male who had just given this call. It may be described as a series of brief, rapidly repeated notes of moderate pitch that could be rendered as *kuk-kuk-kuk*, or *tik-tik-tik*, and this call is a bit harder or sharper than the corresponding call of the domestic cock.

Perhaps as a result of the extreme wariness of the birds, only two copulations of jungle fowl were seen, one on 14 April at 18:00 as mentioned above, the other on 15 April at about noon (12:10). In each case there was very little preliminary action apparent, although the hen crouched just before the male mounted. Copulation closely resembled the pattern seen among domestic chickens and took only a moment or two. On dismounting, the jungle cock circled the hen about one-fourth of the way while facing her and at the same time half dropping the outer wing, *i.e.*, the one on the side opposite the hen, in an incipient wing-flutter. The hen meanwhile shook herself just as a domestic hen does after copulation. In the second observed copulation, it was noted that shortly after mating, the cock began to scratch about in the leaf litter and feed for the first time in over 10 minutes, and soon after copulation the hen resumed scratching.

On the evening of 12 April 1963, while searching on an island in Dholkhand Rao for jungle fowl from elephant back, we discovered a nest of a jungle hen at the foot of a small rohini (*Mallotus philippensis*) tree. The nest consisted of a slight depression lined with just a few leaves and a couple of small feathers. It contained two eggs conspicuous against their background because of their uniform whitish coloration. A hen and a cock were nearby. Next morning one egg was out of the nest several feet away with a puncture hole in it, and that evening the second egg had been similarly treated—the work of jungle crows according to our shikari. Bump and Bohl (1961) state that the normal clutch size in Red Jungle Fowl for the first nest is five to seven eggs with renests having usually three to four. They report 16 wild nests observed in 1960, and in only three had eggs been destroyed, apparently by a predator. Bump (1961) gives the incubation period of the Indian Red Jungle Fowl as 23 days; apparently this figure is based on experience with captive birds.

Jungle hens cluck to their chicks and lead them about. The chicks can fly from a surprisingly early age. Repeatedly, we observed that when a hen crossed a road she walked across while her small chicks, one-fourth grown or less, generally flew across. Some of these chicks were so small that from a distance they gave the

impression of a flock of sparrows flying across the road after the hen. When separated from the parents or when captured, jungle fowl chicks utter distress cries that closely resemble those of domestic chicks.

The coloration pattern of downy Red Jungle Fowl chicks beautifully matches the browns and buffs and dark shadows of the forest floor. One chick we captured was estimated to be only five to six days old and when carefully placed on the ground was quiet and immobile for some time. When seized and held it gave distress cries, and when released it quickly ran off while uttering lighter, more pleasant-sounding, twittering notes.

Very small chicks, estimated to be from one to three weeks old, that we captured had dull yellow legs, but as chicks grow older their legs gradually change to the dark-slaty color so typical of wild jungle fowl.

We have seen partly grown chicks "play fighting" in the manner familiar in domestic chicks. We have no idea how long Red Jungle Fowl chicks stay with the mother in nature. In captivity the period of association with the mother is at least three months, by which time all the down has disappeared from the body except on the chin and upper throat.

RESPONSES TO ENEMIES

Among the animals inhabiting the same type of country as jungle fowl and which we were assured by various expert guides and wardens to be the enemies of jungle fowl were various cats, civets, jackals, hawks, eagles, and owls; crows, monitor lizards, and snakes are said to take the eggs. It is often difficult to evaluate the evidence regarding reported predators. Stomach contents of predators seem rarely to have been analyzed for jungle fowl. The finding of kills and destroyed nests is also uncommon, and the signs may be difficult to ascertain unequivocally. Direct observation of predation on jungle fowl by various animals is exceedingly rare, even by persons with a lifetime of experience in the forest. When questioned, our shikari stated that he had actually seen small forest cats capture jungle fowls. Once during our stay in the Saharanpur Forest Division a leopard passed coughing and growling near the dak bungalow and fairly close to a jungle fowl roost. But the jungle cock in the vicinity of this roost continued his evening crowing, paying no apparent attention to the leopard. Man is very likely the worst enemy of jungle fowl.

Throughout our field study we were impressed by the great wariness of the Red Jungle Fowl. In this respect our experience was similar to that of others who have attempted to study this species in the field. Bump and Bohl (1961), state: "Among many who have never hunted jungle fowl there exists an impression that, since these birds are the progenitors of domestic poultry, jungle fowl must be rather tame even in the wild. Nothing could be further from the truth. Though relatively unconcerned by the wanderings of man about their domain once they sense the element of pursuit they are as wary and cunning as the best of American game birds."

We attempted to locate jungle fowl for further study by means of the dawn crowing and soon discovered that after being disturbed at their roosts the birds would shift the location of these roosts as much as a hundred yards or more on the next night, and furthermore would greatly diminish the frequency of their crowing, even at dawn. This behavior was in marked contrast to the quite tame but unconfined Red Jungle Fowl we had earlier studied at the San Diego Zoo; these birds roosted in the same trees on the zoo grounds for many months at a time.

The Red Jungle Fowl is not a particularly conspicuous bird in its native habitat.

Throughout much of the year there is an abundance of cover for it to hide in, and when disturbed while feeding in the open on the edge of the forest it quickly retreats to cover. Even during the most open times of year, *i.e.*, during the dry season and following episodes of burning of the forest by man, the bird is not easy to detect. Indeed, it seems that under such circumstances its coloration matches that of the environment more closely than at other times of year. The black breast and tail of the cock, and even the bluish-green sheen of the long sickles and tail feathers, closely resemble the coloration of burned patches of ground, while the yellow-orange cape and rufous browns of the back and wings tend to match the coloration of the dead leaves that everywhere litter the ground except in freshly burned forest. The relatively dull plumage of the hen, in which gray-browns, yellow-browns, and dull pinkish-brown predominate, is quite dark and likewise inconspicuous against the dead leaves on the ground. The matching of the environment by the plumage of cock and hen is illustrated by our film (Collias and Collias, 1965). Some other gallinaeous birds that share the Red Jungle Fowl's habitat, including the White-crested Kaleege Pheasant (*Lophur leucomelana*) and the Black Partridge (*Francolinus francolinus*), show convergent resemblances of plumage in the large amount of blackish coloration.

The coloration of small, downy jungle fowl chicks is a model of concealing function, with soft buffs, browns, and black matching the dead leaves and shadows on the ground. This coloration is combined with crouching behavior and absolute immobility in response to parental warning cries. The adults, too, may remain immobile for long periods of time, presumably under conditions when potential danger threatens and when the bird perhaps believes it has not yet been discovered. We once observed a cock and two hens resting under cover of a small bush some 50 yards from our parked car. The cock soon moved off slowly, but as we continued to watch quietly, one of the hens stood watching us without moving a muscle or a feather for 28 minutes.

In contrast to the above behavior were the noisy and conspicuous actions of a hen with two one-fourth grown chicks that we surprised near their roost shortly after dawn one day. The mother, followed by the chicks, flew up into a tree as she gave an alarmed cackle. One of the chicks perched immobile for at least 10 minutes, 40 feet up in the tree. Meanwhile, its mother paced restlessly back and forth on a bough and then flew to other nearby trees, as she continued her conspicuous pacing and raucous cackling for half an hour. The whole demonstration evidently functioned to divert attention of potential enemies from the relatively helpless chicks to the mother.

Sudden discovery of an enemy, under conditions that might require quick action by the bird, may be accompanied by emission of a sudden scream sometimes known as the "hawk call" or the call signifying an aerial predator, and which at once inhibits other vocalizations by jungle fowl. However, such a "hawk call" may sometimes be given in response to enemies on the ground, and it is perhaps more accurately described as a high-intensity alarm cry calling for instant action. We heard this call on several occasions when we could observe no hawk nearby. In domestic fowl this cry induces chicks to run and hide, although we were not fortunate enough to be able to note the response of Red Jungle Fowl chicks in nature to this call. The ordinary cackling cries that we often stimulated by our presence may generally be responses to predators on the ground, and no doubt are frequently given when cats, dogs, and people appear. However, on one occasion when we heard jungle fowl

cackling continuously in the forest and investigated, the only predator we were able to discover was a Crested Serpent Eagle (*Spilornis cheela*) perched in a tree near the jungle fowl. This experience suggests that the cackling alarm cry is given where there is no immediate danger from an already-discovered predator, who is more to be "scolded," thus alerting other jungle fowl to its presence, rather than calling for instant action.

Ordinarily, unless pressed, a flock of jungle fowl prefers to walk away from an approaching man rather than to fly. They seem less alarmed by people on elephant back than on foot. In following jungle cocks about with elephant, we noticed that after having been driven from 100 to 200 yards (91-183 m), a cock tends to circle back into his territory.

It was interesting to stand quietly to one side watching the responses of jungle fowl being slowly driven toward a net by a crew of beaters in the jungle. For example, on 8 June 1963, from a vantage point on the periphery of a beat, we saw four hens and three cocks fly high into the trees, thus eluding capture. These birds, which seemed unaware of our presence, quickly moved into higher branches of the trees as if to get a better view of the beaters, and they remained absolutely silent. Thus, one cock perched some 60 feet up watching the beaters without a sound and also moving very little. Jungle fowl differ from domestic fowl in being strong fliers, and many birds escape over the heads of the beaters or by flying off to one side.

Soon after a group of hens had been surprised and the birds flushed in different directions, we heard a series of disturbed, straining notes of much weaker intensity than the loud alarm cackle made in response to a ground predator. It seems that the birds were reassembling, and quite possibly the call we heard was a "rally call," one that helped bring and keep the birds together under disturbed circumstances.

In its daily encounters with its host of enemies the Red Jungle Fowl probably derives aid from many of its community associates. Often when sitting in the forest on a machan partly hidden by leafy branches, we have been discovered and subjected to a hubbub of scolding alarm cries by a sharp-eyed and noisy crowd of Jungle Babblers (*Turdoides striatus*) or of White-crested Laughing Thrushes (*Garrulax leucolophus*). Each species of jungle inhabitant is no doubt best attuned to detect its main enemy, and to the extent that each species can recognize and profit from the alarm cries of other species a cooperative network of communication or an "intelligence system" for the detection of common enemies must exist. Furthermore, different species may detect the same enemy from different vantage points. Thus, the leopard is perhaps the most important enemy of both the spotted deer (cheetal) and the langur. The deer detects the leopard on the ground and especially through its keen sense of smell, while the langurs with their keen eyesight are in a favorable situation to detect the leopard from in the trees. Both species have special alarm cries that are used by human hunters as good clues to the presence and location of leopard. Langur and cheetal are common inhabitants of jungle fowl country, and it is likely that the Red Jungle Fowl often detects the presence of leopards by the specific alarm cries of these community associates.

COMPARISON WITH OTHER SPECIES OF JUNGLE FOWL

We were able to make brief visits to observe the Grey Jungle Fowl (*Gallus sonneratii*) in its natural habitat at the Mt. Abu game sanctuary in Rajasthan State, India, in the northwest part of the geographic range of this species during the period 18-22 May 1962. We were also able to observe the Ceylon Jungle Fowl (*Gallus*

lafayetii) in its natural habitat at the Wilpattu National Park in Ceylon during the period 26–28 May 1962. But we have not observed the fourth species of jungle fowl, the Green Jungle Fowl (*Gallus varius*) of Indonesia, in its native habitat.

Burning off the low vegetation seems to be much less common or widespread in the range of the Grey and Ceylon species than in the case of the Red Jungle Fowl, and the consequent lack of many fire-blackened areas is correlated with the relatively slight development of black in the plumage of the male in the two former species compared with that of the Red jungle cock. Although not black, the hen of the Red Jungle Fowl is a definitely darker bird than are the hens of the other two species, which have quite a bit of white in the underparts.

At the Mt. Abu game sanctuary there were many gray granitic rock outcrops, and often the Grey Jungle Fowl were seen crossing these outcrops in going from one patch of vegetation to another. When in vegetation, the birds preferred areas covered with shrubs, small trees, and euphorbias to the small, grassy clearings scattered here and there. The general aspect of the cock Grey Jungle Fowl is streaky gray with a dark tail and sickles. It seemed to us that the cape of the male, which looks more gray and white speckled from a distance, rather than gray and yellow, matched the salt-and-pepper pattern of the gray granite rocks, which were favorite crowing sites for the cocks. Many of the rocks were quite dark, and the dark tail and sickles of the male tend to match this background, as well as being inconspicuous in the shadows of shrubbery. Sometimes the rocks had a slight yellowish tinge, and there is a yellow patch on the shoulder of the male Grey Jungle Fowl. In any discussion of concealing coloration one is concerned with probabilities both of background environments and the state of movement or of immobility of the bird in relationship to potential predators.

Although the habitat of the Grey Jungle Fowl of Mt. Abu was definitely more open and rocky than that of any Red Jungle Fowl habitats we had seen earlier in north-central India, west-central Thailand, or central Malaya, we found that the optimal habitat of the Ceylon Jungle Fowl was very similar to that of the Red Jungle Fowl in Malaya. This similarity of habitat is associated with greater similarity in plumage of these two species compared with that of the Grey Jungle Fowl. Thus, together with McClaren Cameron, one morning we counted 24 different cocks of the Ceylon Jungle Fowl crowing within earshot of the road through the forest over a one-mile (1.6 km) distance in the Wilpattu National Park from Kali Villu toward Kanjuran Villu. The Game Ranger also informed us that this area contained the heaviest population of jungle fowl in the park. There were many fruiting trees and shrubs providing food, the ground was soft and easily scratched by birds looking for food, and there were many termite nests present. The vegetation was dense enough to provide good cover but not so dense but that jungle fowl could not walk through it easily—much more easily than a man or other large animal. The forest floor was covered with dry, dead, brownish, orange, or red-brown leaves, and this general coloration is matched by the cape, back, and rufous breast of the plumage of the Ceylon Jungle Fowl. The rufous breast of the cock was not often seen since the birds frequently faced away as they walked from us. The dark tail and sickles are not conspicuous against the pattern of forest shadows. The legs of the Ceylon hen are yellowish; those of the cock are a bright orange or reddish, and those of both sexes thus differ markedly from the dark-slaty color of the legs of the Red Jungle Fowl. The most conspicuous field mark of the Ceylon jungle cock, particularly from close-up, is the bright-yellow patch on the comb. But there are many

bright-yellow sun flecks in the forest, dappled as it is with light, and from a distance of more than about 40 feet (12 m), especially when the cock is immobile, the comb is not conspicuous.

One marked similarity in the food of three species is in their use of succulent fruits. This habit might well help to tide them through the dry season of the year, especially in the case of the Grey and the Red Jungle Fowl. The Ceylon Jungle Fowl (Henry, 1955) and the Red Jungle Fowl may also feed much on termites. This food supply seems to be particularly important during the period of rapid growth of the young. Termites were uncommon at Mt. Abu where we studied the Grey Jungle Fowl, but might be more common in other parts of its range.

Our observations of Grey and Ceylon species of jungle fowl were rather limited for any very firm conclusions on social grouping patterns, but some comparisons are worth mentioning. In both instances we were present during the breeding season of the birds, and the most common thing observed was the prevalence of isolated cocks. Here again, as in the Red Jungle Fowl, the at-least-temporary exclusion of many males from mating activities is probably associated with the pugnacity of cocks. We saw many more instances of Red Jungle Fowl cocks in company with more than one hen than was the case of the Grey or Ceylon species. Ceylon Jungle Fowl hens and cocks were often seen separately, in contrast to the Red Jungle Fowl hens which, when without chicks, almost always had one or more cocks in attendance.

The crowing of the three species of jungle fowl was recorded in nature on tape with a Siera Model Portable all-transistor, battery-driven tape recorder at 1½ inches per second. The actual sounds can be heard on the above-mentioned film (Collias and Collias, 1965). These sounds were put into spectrographic form for precise analysis and comparison of the species-typical voice characteristics (fig. 7). The spectrograms were made on a Kay Electric Company Sona-Graph, No. 662-A, with the tape recordings run at normal speed. Both harmonic analysis and amplitude displays were made in our study of the components of the crowing of each species.

On the standard spectrogram for harmonic analysis (frequency vs. time; see the lower portion of each spectrogram in figure 7), the amplitude, according to the manufacturer, is a function of the density or darkness of the record up to a 6-decibel level of the recorded information and is therefore difficult to interpret with any degree of accuracy. The amplitude display (amplitude vs. time; see the upper portion of each spectrogram in figure 7) provides a more accurate means of measuring the average level of the recorded signal for each instant, over a 34-db range. The peak intensities as shown in figure 7 varied from about 17 to 22 db when the play-back unit was set at a level where the volume of crowing sounds gave much the same subject impression of loudness to the observer's ear as it did when he heard and recorded these sounds in the field at some 15 to 30 meters from the bird. To reduce the possibility of distorting the sounds, a parabolic reflector was not used to magnify the sounds while recording them. However, since the absolute amplitude of sounds varies so greatly with distance from the sound source, only relative differences in amplitude seem of much significance in the comparisons we made. At least there was no obvious difference to our ears in overall loudness of crowing by any of the three species of jungle fowl.

In the case of the Red Jungle Fowl cock (fig. 7a and 7b) a single crowing consists of four component notes, *i.e.*, of four more or less separate and discrete major energy peaks, sometimes rendered onomatopoeically as *cock-a-doodle-doo*. These four notes are, however, run together. The total time span of the crowing is

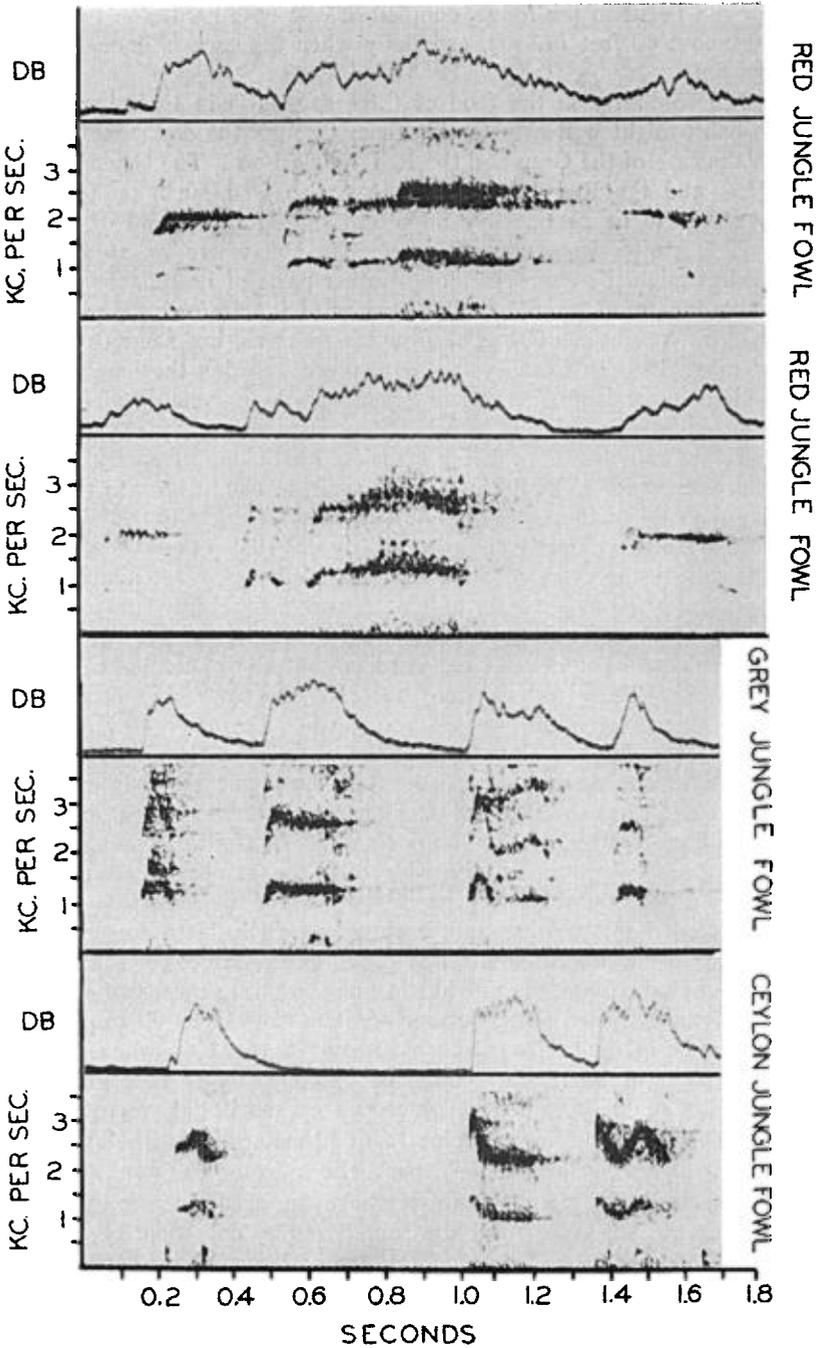


Figure 7. Spectrograms of crowing by cocks of (top to bottom) (a) Red Jungle Fowl in Corbett National Park, (b) Red Jungle Fowl in the Saharanpur Forest Division, (c) Grey Jungle Fowl at Mt. Abu game sanctuary, and (d) Ceylon Jungle Fowl in Wilpattu National Park. Spectrograms made on narrow filter and with display switch at -10 db.

approximately 1.5 to 1.7 seconds. The first three component notes show a successive rise in pitch, while the fourth note drops a little below the pitch level of the first, so that the voice of the cock appears to rise and fall as he crows. The second harmonic is the strongest in the case of each note. The amplitude display measures the relative intensity of the various components of the crowing and shows the third note to be the strongest because it not only contains the highest peaks of intensity (as measured in decibels) but being more sustained at a high-energy level than are the other component notes also contains the most overall energy.

In the voice of the Grey Jungle Fowl cock (fig. 7c) a single crowing consists of four component notes as in the case of the Red Jungle Fowl, and the overall length of the crowing is about the same. But the individual notes are much more discrete and not run together as in the crowing of the Red Jungle Fowl cock. Baker (1928) describes the crowing of the Grey Jungle Fowl cock as "*kuck-kaya—kaya-kuk.*" Our spectrogram shows notes 1 and 2 and notes 3 and 4 to be a little closer to each other, respectively, there thus being two groups of two notes each. Each of the four different notes of the crowing tends to vary in pitch level within itself, whereas each of the four notes of the Red's crowing is more sustained in pitch. The second harmonic in the crowing of the Grey is not very markedly stronger than is its first harmonic, unlike the case for the Red Jungle Fowl. However, there is no difference in pitch level when one compares the strong second harmonic in the voice of both species. The amplitude display reveals no great difference in maximum intensity reached in any of the four notes of the crowing of the Grey Jungle Fowl, but the second note contains most overall energy and therefore often appears to the human ear to be the note emphasized in the crowing. However, there is little difference in energy content between the 2nd and the 3rd note.

The crowing of the Ceylon Jungle Fowl cock consists of only three discrete and well-separated notes (fig. 7d), described as "*chuck—joy-joysee*" by Baker (1928). But the overall length of the crowing, from start of the first to ending of the last note, is only slightly shorter than that of the Red or Grey Jungle Fowl, because there is a marked delay between the ending of the first note and the onset of the second. This prolonged interval between the first and second note results in a markedly different impression to the ear of the observer than the slurring of the several notes in the crowing of the Red or the discrete but more uniformly spaced four notes in the crowing of the Grey Jungle Fowl. In the crowing of the Ceylon male as in that of the Grey, there is a marked variation of pitch within each of the component notes, in contrast to the relatively sustained pitch of the four notes of the Red's crowing. As in the case of the other two species, there is a second harmonic in the Ceylon's crowing. The amplitude display reveals no very great difference in loudness or total energy content of the three notes, and the apparent emphasis to the human ear on the first note in the crowing of the Ceylon cock seems due to the relatively great time interval between the first and second notes.

In summary, there is specificity in a number of different respects when one makes detailed comparisons, aided by modern instruments, between the patterns of crowing in the three species of jungle fowl studied. Such specific differences in pattern are found not so much in the overall length of the crowing as in: (1) number of component notes or major energy peaks, (2) relative loudness and length and therefore of total energy content of the different component notes, (3) relative intensity and energy content of the different harmonics of each note, and (4) systematic

variations in pitch, both between the different component notes of a crowing and within each note.

GENERAL EFFECTS OF DOMESTICATION ON BEHAVIOR

It is useful to draw together in one section the presumed effects of domestication on behavior. We can deduce such effects by comparing behavior of *Gallus gallus* as we have studied it in three different situations: in nature, in the free-ranging population of Red Jungle Fowl at the San Diego Zoo (Collias *et al.*, 1966), and in domestic chickens (Collias, 1943, 1950, 1952; Guhl, Collias, and Allee, 1945; Collias and Joos, 1953). Good reviews of the behavior of the domestic chicken are those by Wood-Gush (1955) and by Guhl (1962). Wood-Gush (1959) has summarized the history of the domestic chicken or domestic fowl. In general the effects of domestication on behavior are quantitative rather than qualitative.

Over most of its geographic range, the Red Jungle Fowl inhabits a secondary forest habitat in association with the cut-slash-burn type of primitive agriculture. Its occupancy of such habitat insures its frequent occurrence near human villages in the forest, and in this sense such an occurrence can be considered a preadaptation to domestication. Similarly, the omnivorous food habits of the wild Red Jungle Fowl help preadapt it to domestication. It obtains a good part of its food by scratching about in the leaf litter that frequently covers the forest floor in the tropics, but unlike domestic fowl is a strong flyer and often feeds in trees on various fruits. The San Diego Zoo jungle fowl, although well able to fly, fed on the ground where they spent almost all their time when not roosting or resting in trees.

In general, the breeding populations of wild Red Jungle Fowl we observed in the forest were less crowded than in the generally larger flocks on the grounds of the San Diego Zoo, while domestic fowl in chicken yards and farms may often be still more crowded in relation to the more-favorable food supply. We found the positions of roosts much more stable and persistent in the zoo jungle fowl than in wild populations of Red Jungle Fowl in nature; this difference is probably due mainly to the protection of the zoo birds from undue disturbance or from hunting by humans. Like the jungle fowl we observed in the zoo, domestic fowl have similarly persistent and favored roosting sites.

The wild Red Jungle Fowl is a much hunted animal and in its natural habitat was far more alert and wary than are domestic fowl, or any of the free-ranging jungle fowl of the San Diego Zoo, which see many thousands of persons each year at relatively close range. In fact, it was our impression that the Red Jungle Fowl in nature is one of the wariest species of birds in the world, in strong contrast to its sheltered and domesticated descendants.

The reproductive behavior in both wild and zoo populations of Red Jungle Fowl appeared similar to that of domestic chickens. The breeding season in the zoo jungle fowl at San Diego paralleled but was more extended than was the case in the jungle fowl of north-central India. Where sufficient hens are available, dominant cocks may be polygynous and keep subordinate cocks at a distance from the hens during the breeding season whether in nature, the zoo, or the chicken yard. However, during the height of the mating season there seemed to be less tolerance of subordinate cocks in the wild than at the zoo, and the subordinates were kept at a greater distance from the hens by the dominant male of a flock. The patterns of fighting behavior are similar in wild and zoo Red Jungle Fowl and in domestic chickens. Copulation behavior is much the same in all three instances, and may

occur without any evident preliminaries except crouching by the hen. In all three degrees of wildness or of domestication, the hen as a rule does all the incubating and brooding, although at the zoo we saw a case where a male Red Jungle Fowl was brooding chicks and seemed to have complete charge of them, since there was no hen in evidence. Banks (1955) has also observed one such instance in captive Red Jungle Fowl.

The voice and repertoire of calls we found to be similar in wild and zoo Red Jungle Fowl and in domestic chickens. Spectrograms (fig. 7) show that the crowing of the Red Jungle Fowl in nature, especially in its relatively sustained pitch, resembles more closely that of the domestic cock (Collias and Joos, 1953) than does the crowing of the Grey or Ceylon jungle cock. But the crowing of the domestic cock is drawn out to a greater length and contains more clear-cut harmonics than does that of the Red Jungle cock. As in domestic fowl the male of the wild and zoo Red Jungle Fowl was seen to crow to assert dominance and territorial rights, and there is also a dawn peak of crowing in each case. In all instances, the cock attracts the hen by a special repetitive note that closely resembles the food call of the hen to baby chicks, and the hen leads the chicks about with the aid of clucking sounds. In each case, there are low- and high-intensity alarm cries that could, respectively, be described as loud, cackling sounds and as harsh screams. The chicks in all three degrees of wildness or domestication utter similar loud, strident chirps, *i.e.*, distress cries on separation from the parent, and give soft, light, rapidly repeated notes on release from stressful situations or on being reunited with the parent.

There is surprisingly little evidence of hybrid populations between wild Red Jungle Fowl and domestic chickens (Rabor and Rand, 1958; Rand and Rabor, 1960). When disturbed by an observer near the edge of a village, wild Red Jungle Fowl seek refuge in the forest, whereas village chickens disturbed in a similar situation head back for the village. Our observations in a few different areas of India and Thailand in this respect tend to agree with those of Rand and Rabor in the Philippines (1960). The latter two authors have suggested that populations of Red Jungle Fowl and of domestic fowl might serve as a model to illustrate how separate races might develop by isolation through different habitat preferences and behavior, even within the same geographic area.

SUMMARY

The purpose of the present investigation was to observe the breeding behavior of the Red Jungle Fowl (*Gallus gallus*) in its natural habitat, and to compare this behavior with that of the domestic fowl (also *Gallus gallus*), of which the Red Jungle Fowl is the ancestor, largely or entirely. It is hoped also that this study will enhance the perspective of the numerous studies done on behavior of domestic chickens by describing the more or less natural conditions under which this behavior evolved from the ancestral type.

The observations reported here of the Red Jungle Fowl were made in north-central India during April-June 1963, in the Siwalik Hills near Dehra Dun and in the Corbett National Park. Comparative observations of Grey Jungle Fowl (*G. sonneratii*) were made briefly at Mt. Abu, Rajasthan State, India, and of Ceylon Jungle Fowl (*G. lafayetii*) at the Wilpattu National Park, Ceylon.

The habitat of the Red Jungle Fowl is largely in secondary forest which has been subjected to burning by man for centuries for purposes of grazing and primitive agriculture. This burning produces blackened areas which the black breast and dark

tail and sickles of the male Red Jungle Fowl match in color during that time of the year when the forest is most open and general visibility greatest. Where Red Jungle Fowl were most common, breeding density averaged about one hectare (2.5 acres) per adult bird, and the different flocks usually roosted some 100 to 300 meters apart. The same roosting trees are used consistently only so long as the birds are not disturbed.

A peak of crowing at dawn may be followed by a secondary peak before sunrise as the birds move to water, with a minor peak before sunset. During the dry season water holes are visited mainly in the early morning and late afternoon or evening. The birds also feed at about these times, and rest, often in or near the roosting trees, during the hot hours of the day. The birds feed on a succession of succulent fruits which probably supply part of their water needs during the dry season. Jungle fowl are omnivorous and eat many insects among a wide variety of other foods. Flights of termites in the area of study were correlated with the presence of many growing chicks.

Crowing is used by the dominant cock to advertise territorial rights and assert dominance. During the breeding season one often sees a single male accompanied by one to three hens, often followed at a distance by subordinate cocks. An apparent excess number of males seen over females during the mating season and the consequent competition for hens may help explain the high degree of male pugnacity. The hens of a small flock may compete aggressively over food and like the cocks probably have a dominance order.

The breeding behavior and vocal repertoire of the Red Jungle Fowl in nature are very similar to those of the domestic fowl of which it is presumed to be the ancestor. The major difference in behavior of the two is the extreme alertness and wary nature of the Red Jungle Fowl. In general, the effects of domestication on behavior have been quantitative and not qualitative.

ACKNOWLEDGMENTS

Many organizations and individuals aided in this study, and to all of them we are most grateful. The field study was financed by the National Science Foundation (Grant GB-34 to the University of California at Los Angeles) and by a fellowship to the senior author from the John Simon Guggenheim Memorial Foundation. The Los Angeles County Museum kindly appointed us Honorary Research Associates. The San Diego Zoological Society together with UCLA and San Diego State College sponsored a preliminary research and orientation project on the behavior and movements of the free-ranging population of Red Jungle Fowl in the San Diego Zoo (Collias *et al.*, 1966).

Harold S. Coolidge, Executive Director of the Pacific Science Research Board, and Shri V. S. Rao, Inspector-General of the Forest Department, Government of India, helped us to establish some initial contacts. Limitations of space here permit us to acknowledge only those persons who quite directly aided or advised us with reference to the study of jungle fowl in India and Ceylon, although many people and organizations in Malaya and Thailand also gave us invaluable aid and orientation. However, special mention should be made of Lord Medway of the University of Malaya and Dr. Boonsong Lekagul of Bangkok, who introduced us to the study of jungle fowl in the wild. The Indian Board for Wild Life encouraged our proposed study, and the Ministry of External Affairs of the Government of India graciously gave us permission to conduct the field study in India.

The Wildlife Preservation Society of India and the Bombay Natural History Society sponsored and considerably aided the project, and the officers and other personnel of these societies were most helpful. We are particularly indebted to R. N. Misra, Honorary Secretary, and G. K. Singh Mann, former Honorary Secretary of the WPSI, and to Sálím Ali, Vice-President, and Shri J. C. Daniel, Honorary Secretary of the BNHS, as well as to Roy Maclaren Cameron of the Nature Study Society of Ceylon, for considerable valuable assistance and guidance that made it possible for us to accomplish our project. The Divisional Forest officers of the Saharanpur and Dehra Dun Forest Divisions, Uttar Pradesh, the Chief Wild Life Warden, U.P., the Wild Life Warden, Corbett National Park, and the Warden, Department of Wildlife, Ceylon, kindly advised us and gave us the permits to stay and work in the forests concerned. Major D. S. Shiva D.F.O. of the Saharanpur Forest Division was especially helpful.

Other institutions and organizations which aided and abetted the study included the Forest Research Institute in Dehra Dun, the Zoological Survey of India, the Nilgiri Wild Life Association, and the American Embassy in New Delhi. Gardiner Bump and Wayne Bohl of the U.S. Fish and Wildlife Service had previously worked on jungle fowl in the general area of our study and generously gave us the benefit of their experience.

Many other individuals also helped with valuable suggestions or in other ways, including: the late William Beebe, Shri Humayon Abdulali, Shri K. S. Nirmalkumar, G. H. Ball, G. A. Bartholomew, B. Biswas, and R. Boolootian, Mr. and Mrs. P. F. Cumberlege, H. G. Deignan, J. Delacour, W. C. Dilger, J. T. Emlen, H. Friedmann, C. R. Grau, G. Gullion, Dr. and Mrs. F. N. Hamerstrom, J. J. Hickey, F. W. Hill, H. Hochbaum, R. S. Hoffman, F. B. Hutt, Dr. and Mrs. E. J. Jay, David Jenkins, Robert A. Johnson, A. L. Rand, S. Dillon Ripley, K. E. Stager, C. Southwick, R. D. Taber, and Sewall Wright.

Local guides and the various Forest Department personnel were of key importance in the forests and like our shikari, Prem Singh, they were a constant source of helpfulness to us.

LITERATURE CITED

- ALI, SÁLIM. 1961. The book of Indian birds. 6th ed. Bombay Natural History Society, Bombay.
- BAKER, E. C. 1928. The fauna of British India. 2nd ed., vol. 5. Taylor and Francis, London.
- BANKS, E. M. 1955. Social organization in the Red Jungle Fowl (*Gallus gallus* subsp.). Unpublished Ph.D. thesis, University of Florida, Gainesville.
- BANKS, E. M. 1956. Social organization in Red Jungle Fowl hens (*Gallus gallus* subsp.). *Ecology*, 37:240-248.
- BEEBE, W. 1922. A monograph of the pheasants. London.
- BEEBE, W. 1926. Pheasants. Their lives and homes. Doubleday, Page & Co., Garden City, New York.
- BUMP, G. 1961. Progress report of the Foreign Game Introduction Program for the period April 1-October 31, 1961. Branch of Wildlife Research, Bureau of Sport Fisheries and Wildlife, Washington, D.C. Rept. 10.
- BUMP, G., and W. H. BOHL. 1961. Red Junglefowl and Kalij Pheasants. U.S. Fish and Wildlife Service, Washington, D.C. Special Scientific Report, Wildlife No. 62.
- COLLIAS, N. E. 1943. Statistical analysis of factors which make for success in initial encounters between hens. *Amer. Naturalist*, 77:519-538.
- COLLIAS, N. E. 1950. Hormones and behavior, with special reference to birds and mechanisms of hormone action. *In*, Steroid hormones, ed. E. Gordon. University of Wisconsin Press, Madison, pp. 277-329.

- COLLIAS, N. E. 1952. The development of social behavior in birds. *Auk*, 69:127-159.
- COLLIAS, N. E., and E. C. COLLIAS. 1965. Jungle Fowl of India and Ceylon. A film, distributed by University of California, Extension Media Center, Berkeley, California, 16 mm, color, sound, 10 minutes.
- COLLIAS, N. E., E. C. COLLIAS, D. HUNSAKER, and L. MINNING. 1966. Locality fixation, mobility and social organization within an unconfined population of Red Jungle Fowl. *Animal Behaviour*, 14:550-559.
- COLLIAS, N. E., and M. JOOS. 1953. The spectrographic analysis of sound signals of the domestic fowl. *Behaviour*, 5:176-188.
- COLLIAS, N. E., E. C. COLLIAS, and P. SAICHUAE. 1964. A field study of the Red Jungle Fowl (*Gallus gallus*) in Southeast Asia and India. *American Zoologist*, vol. 4, no. 3: abstract 22.
- DARWIN, C. 1887. The variation of animals and plants under domestication. 2nd ed. D. Appleton & Co., New York.
- DELACOUR, J. T. 1951. The pheasants of the world. Country Life, Ltd., London.
- GUHL, A. M. 1962. The behaviour of chickens. *In* The behaviour of domestic animals ed. E. S. E. Hafez. Balliere, Tindall and Cox, London, pp. 491-530.
- GUPTA, B. L. 1928. Forest flora of the Chakrata, Dehra Dun and Saharanpur Forest Divisions, Uttar Pradesh. 3rd ed.
- HENRY, G. M. R. 1955. A guide to the birds of Ceylon. Oxford University Press, London.
- HOLDSWORTH, R. L. 1958. Note on jungle fowl shooting. *The Cheetal*, vol. 1, no. 1, pp. 30-34. Published by Wild Life Preservation Society of India, Dehra Dun, U.P.
- HUTT, F. B. 1949. Genetics of the fowl. McGraw-Hill, New York.
- JOHNSON, R. A. 1963. Habitat preference and behavior of breeding jungle fowl in central western Thailand. *Wilson Bull.*, 75:270-272.
- KIMBALL, E. 1954. Genetics of jungle fowl plumage patterns. Proc. 10th World's Poultry Congress, Edinburgh, Scotland. Department of Agriculture for Scotland, pp. 2-5.
- MATHUR, R. N., and P. K. SEN-SARMA. 1962. Notes on the habits and biology of Dehra Dun termites. *Journal of the Timber Dryers' and Preservers' Association of India*, 8:1-18.
- RABOR, D. S., and A. L. RAND. 1958. Jungle and Domestic Fowl, *Gallus gallus*, in the Philippines. *Condor*, 60:138.
- RAND, A. L., and D. S. RABOR. 1960. Birds of the Philippine Islands. *Fieldiana: Zoology*, 35: 414-419.
- SAHAI, R. 1954. Working Plan for the Dehra Dun Forest Division, Uttar Pradesh, 1949-50 to 1958-59. Pts. I and II.
- WOOD-GUSH, D. G. M. 1955. The behaviour of the domestic chicken: a review of the literature. *Brit. Jour. Animal Behaviour*, 3:81-110.
- WOOD-GUSH, D. G. M. 1959. A history of the domestic chicken from antiquity to the 19th century. *Poultry Sci.*, 38:321-326.

Department of Zoology, the University of California, Los Angeles, California, and the Los Angeles County Museum, Exposition Park, California, 1 July 1966.