TERRITORIAL RELATIONSHIPS BETWEEN
CARDINALS AND PYRRHULOXIAS

by

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INTRODUCTION

The Check-List committee of the American Ornithologists' Union (1957) follows Hellmayr (1938) in separating the Cardinal (Richmondena cardinalis Linnaeus) and the Pyrrhuloxia (Pyrrhuloxia sinuata Bonaparte) into different genera. However, other reviewers (Mayr and Amadon, 1951) have indicated that these two species may be congeneric. The existence of a second species of Cardinal (Richmondena phoenicea Bonaparte), which shows structural tendencies in bill structure toward the Pyrrhuloxia, further suggests the possibility that the two are congeneric. Ridgway (1901) separates the two genera primarily on the basis of the bill structure. Although there is no question as to the validity of these differences, the question arises as to whether this may be utilized as a so-called "generic character" in this case. Simpson (1945) points out the basic aspect of the genus as a group of similar species. The concept does not regard the genus as a hierarchical category based on one or few character differences, but rather as a category stressing groups of similar characters shared by a natural evolutionary group of species. In this respect ecology and life history are important considerations as are morphological characters. This is consistent with the modern concept of the biological species.

There are many similar features, both morphological and

ecological, that Cardinals and Pyrrhuloxias share. A crest is present in both, that of the Cardinal being broader and not as spike-like as the Pyrrhuloxia's. Although the Cardinal is almost completely red, as opposed to large areas of gray in the Pyrrhuloxia, the latter shows similar placement of red colors in the wings, tail and crest. This is especially evident in the females. Cardinal males have a black facial mask, whereas Pyrrhuloxia males have a red one. The degree of sexual dimorphism is identical in both species. In size the Arizona Cardinal averages nine grams heavier than the Arizona Pyrrhuloxia. There are undoubtedly numerous anatomical similarities as well. Similarities will likewise be shown in the voice and general ecology of these two species. The Cardinal is apparently a much more adaptable species having 16 subspecies (Friedmann, Griscom, Moore, 1950; A.O.U., 1957) distributed over most of the United States and Mexico. The Pyrrhuloxia consists of only three races restricted to northwestern Mexico and adjacent border of the United States.

The purpose of this paper is to report the findings of a field study on the territorial relationships between Cardinals and Pyrrhuloxias, undertaken with the idea of showing the similarities and/or differences between them, so as to help support or deny their present generic separation. It is also the purpose of this paper to present a better understanding of their life histories, behavior and interrelations in an area where they occur together.

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METHODS AND MATERIALS

A forty-two and four tenths acre area, in the San Xavier Indian Reservation, 10 miles south of Tucson, Pima County, Arizona, was selected as a permanent study site. Both species occur here as abundant residents in the same habitat, and afford excellent opportunities for a comparative life history study. The study area, situated on the first step lowlands of the Santa Cruz River, contains Mesquite (Prosopis juliflora) woodland with an understory of Gray-thorn (Condalia lycioides). Elderberry (Sambucus) and Hackberry (Celtis) are common in the hedge rows. Much of the mesquite has been cut out and the fields cultivated, but these fields have been unused for several years. A variety of weeds, such as Johnson Grass (Sorghum) and Tumble weed (Salsola kali) among others, have overgrown them (see Plates 1-6). Old irrigation pumps and Indian houses, some in use and others not, are scattered around at various intervals (see figure 1).

Within the study area many feeding stations, baited with red milo seed, were established. Only stations 6, 3, and the privy (see figure 2) were maintained with any consistency. The other stations were baited only when it was necessary to band, or to obtain information on specific birds. These stations, as well as water supplies and other places that birds were noted to frequent, in and around the study area, were used as observation posts and banding stations. Small Bailey

Figure 1. Portion of San Xavier Reservation showing study area.

Figure 2. Study area showing feeding and trapping stations. Numbers represent feeding stations.

traps were set at these feeders and locked open. After the birds had become familiar with them, they were set for capture. Japanese mist nets were frequently used to capture birds.

Birds, in and around the study area, were banded with United States Fish and Wildlife Service aluminum bands and with celluloid color bands so that individuals would be easily recognized in the field. Trapping and banding were continued throughout the study and resulted in the color marking of 38 Cardinals and 84 Pyrrhuloxias. A total of 95 days, with an average of three and one-half hours per day, was spent in the study area from September 30, 1958, to December 18, 1959.

Observations were made with the aid of a 15-25 power spotting scope and with binoculars. A blind was often used at various locations to aid observation. The area was crossed and recrossed and the position of marked birds, their songs, nest sites, fights and other behavior were noted in a field note book. Territories were determined primarily by noting the positions of the singing male, and also the points where fighting and chasing occurred. It was discovered that nesting began about the first of May and continued until August. A tabulation of the points where marked males were found during this time would then verify these territorial boundaries (see figure 3). Many of the boundaries, however, were located in fields where the birds were not likely to be found in a stationary position. The boundary lines in these places were then determined by the flight course of the birds.

VOICE

Song has long been recognized as one of the essentials in the territoriality of birds. Nice (1941) points out that as far back as 1903, Altum "stated all the essentials of the territory theory, including the modern view of song as a threat to other males and an invitation to a female." Singing is important in the establishment and maintenance of territory in both the Cardinal and the Pyrrhuloxia.

The songs of the Cardinal and Pyrrhuloxia are quite similar, often being indistinguishable. Generally the Cardinal has a somewhat more musical and full bodied song. Both the male and female of each species sing, although the female Cardinal sings much more frequently than does the female Pyrrhuloxia. The song of the female Cardinal is essentially the same as that of the male, and they cannot be distinguished in the field. Laskey (1944) says that in the case of the Eastern Cardinal the difference between the male and the female song is no greater than the difference between the songs of two males. She also indicates that the female does not begin to sing until later in the season. Apparently song in the female has no function related to territory, and only on a few occasions have I heard the female singing without her mate. Duet singing is very common between members of a pair, with the male and female singing either simultaneously or

alternating. This is most common in the spring just prior to nesting, and has been reported as early as February for the Eastern Cardinal by Shaver and Roberts (Laskey, 1944). Duet singing continues throughout the nesting season probably aiding in the maintenance of the pair bond. It decreases markedly after the young are hatched.

The female *Pyrrhuloxia* is rarely heard, although her song may be as loud and forceful as the male. One female came up in defense of a nest that was being examined and sang a few, short, halting songs in a low voice. These were of the same type as the males only much shorter. On only one other occasion did I observe a female singing in the field. At this time her song was identical to that of the male.

Laskey (1944) has been able to differentiate between twenty-eight different songs in the Eastern Cardinal. While there are certainly a great many variations to their songs, I find it convenient to reduce these to four basic patterns. These are listed using phonetic interpretations and hyphens to denote increased velocity.

1. cléo cléo cléo cléo
2. Chewy chewy chewy chew-chew-chew-chew
3. whatier' whatier' whatier'
4. whéet whéet whéet weet-weet-weet-weet

Any one of these types may be ended in a high pitched, rapid, musical trill. Different males, as well as the same male, show variations of these basic types. Chewy chewy may become cleuy cleuy and cleo cleo may become pew pew. Only rarely do combinations of two of these types occur during one song period. Besides these songs, the Cardinal has a

distinctive call, tic tic tic tic-tic-tic-tic-tic. This is used by both the male and the female with equal vigor and volume. It is very high pitched and has a musical quality. It is never used unless the young have hatched, at which time it becomes common. It is most noticeable when the young are threatened. In one intensively observed pair, the birds did not use this call until at least the day that the young hatched.

As with the Cardinal, I have reduced the songs of the *Pyrrhuloxia* to four basic patterns.

1. keyrra keyrra keyrra
2. queet queet queet
3. weet tier-weet tier-weet
4. kew kew kew

These songs are just as variable as those of the Cardinal, and it is in the variations that they overlap and become indistinguishable. Kew kew kew may become pew pew pew or even kewa kewa kewa, and queet queet may become wheet wheet or weet weet. Many times an extra note wat may be added to any of these types and on occasion uttered alone. The *Pyrrhuloxia* has a call, chick chick chick tic-tic-tic-tic-tic, used primarily during territorial disputes and as a contact device between members of a pair. When one bird, or a pair, invades the territory of another, this call becomes agitated and very loud. It is used by all of the participants in the following dispute. When members of a pair are separated, this call will be exchanged until the pair becomes reunited.

In neither the Cardinal nor the Pyrrhuloxia is any one type of song preferred over another. The Cardinal will use one type for an extended singing period and then may switch to another. The Pyrrhuloxia, however, will sing any or all of the song types listed during one period. During a twelve minute period, one male Pyrrhuloxia sang as follows:

<u>keyrra keyrra keyrra</u>	two times
<u>kew kew kew kew</u>	eight times
<u>queet queet queet</u>	eight times
<u>keyrra keyrra</u>	fourteen times
<u>tier wat wat wat</u>	five times
<u>pew pew pew</u>	three times
<u>kew kew kew kew kew kew</u>	thirteen times

On another occasion this same male sang as follows:

weet tier-weet tier-weet tier-weet
keyrra keyrra keyrra
queet queet queet queet
kew kew kew kew kew

This variety during one singing period is fairly typical of any male Pyrrhuloxia at the height of the breeding season.

In both species, these four types of song are used primarily in the proclamation of territory. This is especially true during the period of incubation. While the female is on the nest the male often sings from a nearby tree. Occasionally during the day competitive singing, between males of the same species, may be heard. This is

equally as common between Cardinals as between Pyrrhuloxias. The males sing either in unison or alternate with each other. This is most common between males of adjoining territories, but may sometimes be heard between widely separated males. Early in the morning this singing sounds like a large chorus with all birds singing together.

The call of the Cardinal is essentially a high pitched, sharp tsip. It is heard throughout the year, and appears to be a contact call at least during the breeding season. The Pyrrhuloxia call note is much the same except not as high pitched nor as musical. It seems to be used primarily in the winter and gives way to the chick chick call, described earlier, during the breeding season. The food call of the young Cardinal is not as loud nor as harsh as that of the young Pyrrhuloxia, and it is more frequently restricted to only a single note.

Songs of both species were heard as early as the first of February in the Cardinal and the middle of February in the Pyrrhuloxia. In both it was not until the middle of March that singing reached its peak. Singing subsided during the latter states of incubation and was rarely heard after the young were hatched. Singing was renewed after the first brood became independent if a second was attempted. September song was reduced to only a few scattered half-songs by one or two individuals.

The songs are homologous and apparently serve the same function. An apparent adaptation to eliminate confusion in singing is the variety of song types used by the Pyrrhuloxia during one singing

period, and the repetition of one song type by the Cardinal.

Another way of pointing up what difference exists is the duet singing found only in the Cardinal. On the other hand, similarity in songs of the two species on the same territory would strengthen the territory for both.

NESTING

Nest building is apparently carried out primarily by the female of both species. Hodges (1949) records that both sexes of the eastern Cardinal take part in the construction of the nest, but the female "takes the lead". Observations on one Cardinal and one Pyrrhuloxia nest under construction showed only the females building, while the males stayed far back in the trees singing frequently. Most nest material, with only a few exceptions, was gathered within the established territory. I never saw nest material gathered within the territory of another pair.

Nests and nest sites of both species were very similar. In the study area both preferred to nest either in Mesquite or Gray-thorn. One nest of the Pyrrhuloxia was found in Elderberry. In other areas around Tucson, Cardinals were found to use Tamarisk trees (Tamarix), and Pyrrhuloxia nests were not uncommon in Palo Verde (Cercidium). Both species seem to prefer thicker patches of brush or dense hedge rows, however, the Pyrrhuloxia was able to utilize more open situations.

The nest of the Cardinal was generally constructed of dead material, although green twigs and stems were sometimes added to the outside. The cup was often poorly lined, and composed of only a few

rootlets, horse hairs, grass stems, and/or vine tendrils. The bulk of the nest was composed of thin strips of bark and plant fibers, generally supplemented with grass and soft plant stems. Often on the outside there were a few heavier twigs, never more than one-sixteenth inch in diameter. In general the nest was more loosely built than the *Pyrrhuloxia*'s and eggs could sometimes be seen through the sides and bottom. Several nests were found to contain tissue paper and paper napkins on the outside. Measurements of nests, as compared with those of the *Pyrrhuloxia* are given in figure 4.

Brandt (1951) writes of a nest found at San Xavier Reservation, "Nest situated seven feet up in frail fork of an inch thick mesquite sapling, among small shoots, easily removed, bulky, ragged; eggs visible through sides of nest; base made of three wide, flat leaves, the sides of tawny bark strips, long weed stems; lining scanty, of meshed, brown rootlets."

The *Pyrrhuloxia* nest was almost always constructed of dead material. Out of twenty nests found only one contained green material, and this amounted to only a few mesquite leaves that had been added to the outside. The nature of the material gives the nest a very decided grayish appearance with brownish highlights. The cup was usually lined with rootlets, always with more on the bottom than on the sides. Occasionally a nest was lined with thin strips of bark, horse hairs, or very small plant stems and fibers. Sometimes no lining was discernible. The bulk of the nest was fairly compact and composed of soft plant and grass stems and fibers. Only rarely were strips of bark

	CARDINAL			PYRRHULOXIA		
measurement	number of nests	range	average	number of nests	range	average
height of nest above ground	8	5-15 ft.	8 ft.	20	5-15 ft.	8 ft.
outside depth	7	2.5- 3 in.	2.7 in.	8	2.3- 3 in.	2.5 in.
outside diameter	7	3.8- 5 in.	4.5 in.	8	3.5- 4.3 in.	4.0 in.
inside depth	7	1.2- 1.7 in.	1.5 in.	8	0.7- 2.2 in.	1.5 in.
inside diameter	7	2.8- 3.5 in.	3.0 in.	8	2.5- 3.3 in.	3.0 in.
outside minus inside depth	7	1.0- 1.3 in.	1.1 in.	8	0.7- 1.7 in.	1.2 in.
outside minus inside diameter	7	0.7- 1.7 in.	1.2 in.	8	0.5- 1.5 in.	1.0 in.

Figure 4. Measurements of Cardinal and Pyrrhuloxia nests from the Tucson Area, Arizona.

used. On the outside there were a few heavier twigs that stuck out away from the nest. These were never more than one-sixteenth inch in diameter. In one case, seed pods from the Palo Verde had been added to the outside. The nest was generally smaller and more compactly built than that of the Cardinal. See figure 4.

Brandt (1951) describes one nest from Cochise County, Arizona, as "situated $5\frac{1}{2}$ feet up in a bush mesquite shrub of many boles; a gray affair, made of a variety of weed stems and some cobwebs, but no large leaves or pepper grass as used by the Cardinal; lining of pale brown rootlets; nest neat, small, compact, with well made rim." Bailey (1928) writes of the nest as "In mesquite and thorny bushes, small and compactly built of twigs, inner bark, or coarse grass, lined with a few rootlets or fine grass and fibers."

The Cardinal was much more apt to place its nest against a major trunk of the tree than was the *Pyrrhuloxia*, but both seemed to prefer to place the nest among the many small twigs that come off of the secondary branches. Neither species anchored the nest very securely to the twigs or branch on which it was placed.

The eggs of both species are very similar. Reed (1904) says of the Cardinal eggs, "three or four, and sometimes five, white or pale bluish white eggs are laid; they are varied in markings but usually profusely spotted, more heavily at the large end, with reddish brown or lavender." Of the *Pyrrhuloxia* he writes "Their eggs are like those of the Cardinal but average smaller, although the ranges overlap so that the eggs cannot be distinguished." In fresh eggs that I have

examined from Arizona, those of the Cardinal have a definite bluish background, whereas the background in the Pyrrhuloxia egg is a dull white. Egg dates for the Arizona Cardinal run from May 4 (Brandt, 1951) to August 11. Those of the Pyrrhuloxia run from May 8 to July 29. From my observations, egg laying may occur any time during the months of May, June, July and early August. The most active period seems to be during the last two weeks in May for the Cardinal, and the first week in June for the Pyrrhuloxia. Brandt (1951) writes of the Cardinal, "The average date, however, when the species begins its serious nesting duties is during the middle third of May." For the Pyrrhuloxia he says "Here from the last week in May to the middle of June this bird lays its clutch of two or three Cardinal-like eggs. The height of the season, however, is during the first hot week of June."

Clutch size of the Cardinal ranged between two and four eggs during the time of this study, and averaged three. That of the Pyrrhuloxia varied between two and three, both being equally common. In one observed case, incubation in the Cardinal required fourteen days from the laying of the last egg. One set of Pyrrhuloxia eggs also required fourteen days from the laying of the last egg. Only the females of both species were observed to incubate, although the males often visit the nest at this time. Contrary to the statement by Brandt (1951), Cardinals may have a second brood if their first nesting is successful. Two successful broods were noted in each of two color marked pairs in the study area. In one case the second brood was

started before the first had become fully independent. I have no information as to a second nesting in the *Pyrrhuloxia*.

Once out of the nest the young are accompanied by the adults for over a month. Young Cardinals tend to remain in the territory of their parents until they become independent, and even longer. The young of pair 3 (see figure 5) remained with the adults even after they were fully grown and completely independent. Young *Pyrrhuloxias*, possibly due to smaller territories, may leave the territory shortly after leaving the nest. The young of pair number ten were seen in the territory of a neighboring pair only three days after leaving the nest.

The eggs and nests are very similar with some differences merely reflecting the lesser size of the *Pyrrhuloxia*. The somewhat later nesting of the *Pyrrhuloxia* may be a development towards reducing competition between these two species. The ability of the *Pyrrhuloxia* to utilize more open situations for nesting may be a reflection of adaptive differences accumulated during an evolutionary period when these species were not sympatric.

WINTER BEHAVIOR

By the first of September most of the young have become independent of the adults. Song has almost ceased and no territorial activity can be detected. The young of the year move about widely and are not restricted to any particular location. The adults, however, seem to be restricted to a definite home range. Cardinals appear to be much more restricted to such an area than are Pyrrhuloxias. During the winter months there were many adults of both species banded within the study area. Since many of these were never seen again, and since the birds that had territories here the previous summer stayed within the area (see figure 3), it is presumed that the increase was due to young of the previous year or to adults that had failed to establish territories the previous summer.

Loose feeding and roosting flocks, containing both species, were formed. These flocks were not integrated, although the male Cardinals appeared to be more dominant than other birds. There were always birds joining and leaving a flock and often a bird was observed feeding alone. When the flock was disturbed, the individuals either left as a group or singly in different directions. These flocks appeared to have a nucleus of the same adult birds which, during the summer, had territories in the same area. The only antagonistic be-

havior was a supplanting attack used to take over a good feeding spot from another bird. This was more often of an intraspecific nature, but without relation to sex. Individual Cardinals and Pyrrhuloxias were no more antagonistic toward each other than toward a great variety of other species such as the Brown Towhee (Pipilo fuscus), Abert Towhee (Pipilo aberti), Green-tail Towhee (Chlorura chlorura), and White-crowned Sparrow (Zonotrichia leucophrys).

Molt apparently occurs just once a year, and this is during the last two weeks in September and the first three weeks in October. By the last week in October all of the Cardinals and Pyrrhuloxias have attained fresh plumage. The bright summer plumage is apparently acquired through the wearing away of the gray feather tips obtained by the fall molt.

Both the Cardinal and the Pyrrhuloxia become very quiet, shy and elusive during the winter months. It is not until territorial activity begins in the spring that they get into the tree tops and become conspicuous.

During the winter there is great similarity in the behavior of these two species. They forage together in the same flock and roost together at night. No friction between them can be noticed. It is tempting to say that here is a case which seems to go against Gause's principle (Gause, 1934). This, however, may not be true as the great difference in bill structure implies that there is a basic difference in their food habits. This is sufficient to allow complete utilization of the same area simultaneously. The basic similarity in molt implies a close phylogenetic relationship.

TERRITORY

Cardinals defend their territories only against trespass by other Cardinals; Pyrrhuloxias defend their areas from Pyrrhuloxias only. As shown by Hinde (1956) definitions of territory are as numerous and varied as the species that exhibit it. In this paper, territory is defined as that area, within the home range of an individual, which is maintained and defended against members of its own species, and in which the birds sing, nest, raise young and for the most part restrict their activities. Since territory is maintained through singing, fighting and chasing, it is possible to plot the respective territories by noting locations of such behavior. Short excursions were sometimes noted to points outside this territory, usually for the purpose of obtaining water or food. These trips were always of short duration and followed by a quick return. Territory therefore, does not include all areas visited by these birds. Within each territory there was a definite center of activity which was a circle about the nest. Here the birds spent most of their time, especially in the afternoon hours. It was here, also, that most of the singing occurred.

Establishment:

With the breaking up of winter flocks in late February and

March, the males of both species became highly pugnacious. Laskey (1955) noted that the territorial defense of the Cardinal was not as pugnacious as that of other birds such as the Mockingbird. Hodges (1949), on the other hand, found the Cardinal to be highly pugnacious and to do a considerable amount of fighting. I find a situation somewhat intermediate between these two extremes. Most contacts, especially later in the season are merely chases with the intruding bird giving ground rapidly. On April 7 there were as many as five male Cardinals chasing each other about, but no serious conflicts were noted. The most vicious encounter that I observed was between two males on March 30. One male chased another for several minutes and actually pulled out one of the fleeing male's tail feathers. The dominant male of this chase, however, was the most pugnacious male in the area, and he had already set up a territory in the area of the chase. The *Pyrrhuloxia*, on the other hand, was much more aggressive and often fought, especially before the territories had become firmly established. The female was equally as pugnacious as the male, before nesting began, and upon one occasion when two pair met all four engaged in a vigorous fight. Once nesting began the females became quite retiring and usually left defense of the nest up to the male.

In both species establishment, as determined by the conflicts between males, began slowly towards the last of February and increased to a high pitch by the last of March. Fighting continued during April but tapered off during the rest of the breeding season. During this period, only tentative areas were set up as territories. Later on,

these were altered and became stabilized. In the *Pyrrhuloxia* this was accomplished by movements of the pair about the periphery of their territory, and the consequent meeting with an adjacent pair, followed by fighting. This type of activity was never observed in the Cardinal.

Maintenance:

Territories are maintained almost entirely by the males of both species. The female assists in defense only when the immediate area of the nest is threatened for an extended period of time. At times she does not even do this but flies off and leaves defense completely to the male. Territory is apparently maintained in three ways: combat, proclamation, and patrolling.

Combat was noticed in both species, but was much greater in the case of the *Pyrrhuloxia*. An intruding bird would be met, usually near the boundaries of the territory and either a fight or a chase would follow. In all cases observed, the intruder was forced to leave the area. If contact was made well within the territory, the intruder was much more prone to take flight and a chase resulted. If contact was made near the boundaries of the territory then a fight was more likely to occur. For the most part, intrusions were made on the part of a male from an adjoining territory. This rarely involved deep penetration and was usually made to obtain water or food from a good area.

Proclamation of territory was through intensive singing on the part of the male. It was most frequent during the early morning, especially in the Cardinal, but could be heard at all times of the day.

This singing would usually be from a favored site within the territory and usually near the center of activity. Proclamation appeared to be the major type of territorial maintenance.

Patrolling was noticed only in the Pyrrhuloxia. After the initial singing in the morning the male would make the rounds of his territory singing a few songs, first in one bush and then the next, until a complete circuit had been made. In one observed case the male had a definite pattern that was usually followed each morning. Cardinals did wander about their territories while the female was on the nest, but this was not accompanied by intensive song and was very irregular.

Once the young are out of the nest, territorial defense and maintenance is reduced, and may stop entirely if it is late in the season. If a nest is destroyed, territorial activity increases although it never reaches the peak of the initial activity.

Composition:

Within the limits of the study area, six Cardinal and ten Pyrrhuloxia territories were established. (see figures 5-6). The total portion of the study area occupied by Cardinal territories was 23.1 acres or 54.5 percent. That of the Pyrrhuloxia was 25.5 acres or 60 percent. All of the mesquite woodland within the study area, except for the open mesquite patch (see figure 2, and plate 5), was utilized by Cardinals for territories. All except for a small portion of the north mesquite area was utilized by Pyrrhuloxias. An average of 45 percent of each Cardinal territory, and 43 percent of each

Pyrrhuloxia territory, included mesquite woodland (see figure 7).

Certain areas seemed to be preferred by both species. These were places which had a good food supply, water, and suitable nesting sites. The artificial feeding stations, established during the winter, attracted both in great numbers. These areas were especially preferred if there was suitable mesquite near by to offer cover and nesting sites. Station number three was close to the south mesquite woodland and thus afforded excellent nesting opportunities. This was the scene of the most numerous and fierce encounters. Station number nine, on the other hand, was out in an open field and was seldom, if ever, defended by either species, although it was occasionally visited.

The nesting area of the Cardinal appeared to be much more restricted by the density of woodland than was the Pyrrhuloxia. An example of this was the fact that, although Cardinals were seen and heard to sing from the open mesquite patch, none established a territory there. One pair of Pyrrhuloxias, however, was able to establish a territory at this spot and raise one family of at least two young. Outside of Tucson, Arizona, Cardinals were found nesting in hedge rows between open fields, but these were always fairly dense. In these same areas the Pyrrhuloxias were often found nesting in trees with little or no vegetation around them.

Both Cardinals and Pyrrhuloxias appear to require an open field within the limits of their territory. In Hinde's (1956) excellent review of territory he indicates that food plays an important role in the territoriality of many birds. Since both the Cardinal and

Fig. 5: Territories of Cardinals showing nest sites.

Fig. 6: Territories of *Pyrrhuloxias* showing nest sites.

the Pyrrhuloxia are primarily seed eaters, as shown by McAtee (1908) it would be expected that they would require just such weedy areas within their territories.

Size and Shape:

The four Cardinal territories, whose boundaries were completely within the study area, ranged between 1.5 and 3.9 acres with an average size of 3.7 acres. There were seven Pyrrhuloxia territories completely within the study area and these ranged from 1.3 to 3.5 acres. The average being 2.5 acres (see figure 7). It should be realized, however, that these figures are only close approximations, as the boundaries between territories were not thin lines, but bands up to five or ten yards wide.

The shape of the territories of both species tended to be roughly circular. They were, however, modified by the landscaping and by other factors. Territories were modified to cover both mesquite woodland and open fields. Hedge rows afforded greater penetration into open areas as seen by the pair of Pyrrhuloxias in territory number seven (see figure 6). The Pyrrhuloxia territory number six was very compressed by the six other territories around it. This resulted in a long and thin territory which included both mesquite woodland and a little open field.

The size, shape and position of the territories of the Cardinals and Pyrrhuloxias were remarkably similar. This was so striking that if the reader were not aware that there were two species involved, he might think that they were maps of the same species during each of two successive years. The difference would then seem to be due

to a greater number of birds present one year as compared with the other year. For example, Cardinal territory one was roughly equivalent to Pyrrhuloxia territory number one plus number three. Cardinal territory number two and Pyrrhuloxia territory number four were almost identical, as were Cardinal number three and Pyrrhuloxia number seven. Pyrrhuloxia number six appears to be squeezed in between many others so that were it not there the other territories would be very similar to the corresponding Cardinal territories. In the study area the ratio of the number of Cardinal territories to those of the Pyrrhuloxia was 1 to 1.6. The ratio of territory size was 1.5 to 1. Therefore, the differences were due to the greater numbers of Pyrrhuloxias than Cardinals. Population pressure appears to be a major factor in regulating the size and shape of territories.

The size and shape of the territories remained remarkably stable during the breeding season. A few minor fluctuations in territorial boundaries, however, were noticed. These were primarily the result of the shifting of the center of activity when a new nest was built. If the new nest was built on the opposite end of the territory from the old one, then the region of the old nest, provided it was near the edge of the territory, was not defended as often nor as vigorously as previously. If at this time the adjoining pair also shifted its center of activity towards the vacated point, then it was possible for this second pair to take over a part of the first pair's territory. This was noticed in one nesting of the Cardinal and two of the Pyrrhuloxia (see dotted lines in figures 5 and 6).

CARDINAL				PYRRHULOXIA			
pair	territory	mesquite	% mesquite	pair	territory	mesquite	% mesquite
# 1	7.1 a.	3.0 a.	*	# 1	3.3 a.	2.3 a.	*
# 2	3.9 a.	0.8 a.	19%	# 2	1.3 a.	0.8 a.	27%
# 3	3.1 a.	0.5 a.	16%	# 3	2.9 a.	0.7 a.	25%
# 4	4.1 a.	2.1 a.	51%	# 4	3.5 a.	1.8 a.	50%
# 5	3.5 a.	3.3 a.	94%	# 5	3.3 a.	1.7 a.	52%
# 6	1.5 a.	1.4 a.	*	# 6	2.2 a.	1.2 a.	54%
				# 7	2.2 a.	0.4 a.	18%
				# 8	1.3 a.	1.0 a.	*
				# 9	0.8 a.	0.8 a.	*
				# 10	2.3 a.	1.8 a.	78%
* average	3.7 a.	1.7 a.	45%	average	2.5 a.	1.2 a.	43%

Fig. 7. Size of individual territories and amount of mesquite woodland within each, in acres.

* Only those territories which were completely within the study area were averaged.

In the case of Cardinal pair number three, the third attempted nest was abandoned and, since it was very late in the breeding season, territorial behavior became very lax and most of this male's time was spent toward the northern part of his territory. Cardinal pair number five at this time, had young that had just left the nest and the family group spent much of their time at the southeast edge of their territory. Several encounters between the males of these two pairs were noted, at the territorial boundary, but pair number five was able to gain control of a small portion of the other pair's territory.

The two cases involving the Pyrrhuloxia were examples of a change in nest sites. The pair in territory number one first nested at the southern end of its territory and that territorial line was thus strongly defended. Concurrently pair number three had a nest farther to the south and there was not much conflict between the two. Both nests were abandoned about the same time and both pairs moved their center of activity northward. Pair three moved almost to the border of the two territories and re-nested while pair one moved farther north and their new nest was never found. This resulted in a shift of territorial boundaries. A small amount of fighting was noticed at first but this lasted only a few days. Essentially the same thing happened with pairs number five and seven.

Nest sites were placed without regard to the size or shape of the territory. Some were in the middle and others were at the edge of the territory (see figures 5 and 6). Similarly there was as much randomness with regard to placement according to the mesquite woodland,

although it generally appears that the Cardinals and Pyrrhuloxias tended not to nest near each other. The fact that the Cardinal pair number five and Pyrrhuloxia pair number six had concurrent nests only three yards apart, shows that this factor is not critical.

Functions:

In his comprehensive review of territory, Hinde (1956) discusses various functions that workers in this field have attributed to territorial behavior. He also states that "While detailed quantitative studies are rare, theories about function must remain unproven. It is clear, however, that the function varies enormously between species." Although it was impossible to come to any direct understanding as to the functions in the territorial activity of Cardinals and Pyrrhuloxias, a few comments seem warranted.

Food supply apparently plays only a minor role in the territorialism of these birds. Earlier in this paper I have shown that most territories included at least a small amount of open field containing a good seed supply. These areas, however, must not have been completely adequate as birds of both species were often noticed feeding together in open fields outside of their territories. No fighting or chasing was noticed on these occasions. During the height of the breeding season two color-marked male Cardinals were noticed fighting near the center of one's territory. A chase ensued and continued to the boundary between their respective territories. At this point the chase stopped and both birds appeared to feed within a foot of each other. Although this may have been the "substitute activity" of Tinbergen (1939), it is thought by the author that if

food were one of the major factors in territoriality, the mere act of feeding in close proximity, regardless of the cause, would have aroused aggressive behavior, rather than suppressed it.

The size, shape and position of territories, along with the almost identical amount of woodland within each, suggests that the ecological requirements are extremely similar for the two species. Differences in ecology which cause a different geographic distribution of the two are not evident at the study area where they both occur and both utilize the same environment in the same way. Not only do their territories overlap, but in many instances they are congruent. It has been suggested earlier that only a different population pressure, can account for the differences which are merely a matter of size. Territory, therefore, would be important in the spacing of the birds throughout the area. The existence of home ranges permits the birds to become familiar with the area and thus strengthens the territorial abilities of these birds. The influx of birds into the area during the winter makes available replacements for established birds that have disappeared or died.

Territory and its maintenance is similar and homologous in these species, with only minor differences showing up in connection with ecology, population, and body size. Territoriality serves to spread out the breeding pairs so that interference will be reduced to a minimum. Food is considered only a minor factor in the function of territory in these two species.

SUMMARY AND CONCLUSIONS

Territorial behavior and other aspects of the life of the Cardinal and Pyrrhuloxia, in southern Arizona, are basically similar. The songs are homologous and at times indistinguishable. These are of prime importance in the establishment and maintenance of territories. Song may also aid in pair formation, but only in the Cardinal is it involved in a definite ritual duet which strengthens the pair bond. The female Pyrrhuloxia is rarely heard in the field. A second type of vocalization is present in both species, but these are not homologous. The Cardinal is the first to begin singing in the spring, while in both singing is almost nonexistent by September.

The nesting cycle and habits appear to be almost identical. The Pyrrhuloxia reaches the peak of its breeding season a week or two later than the Cardinal. This may be a natural consequence of the later beginning of song in the Pyrrhuloxia. These facts may be important in avoiding competition, since their requirements are so similar. Other differences are the slightly smaller average clutch size, egg size and nest size of the Pyrrhuloxia. These differences are in agreement with the slightly smaller body size of the Pyrrhuloxia. The ability of the Pyrrhuloxia to nest in more open situations suggests another mechanism for reducing competition. Only

the Cardinal was observed to have two successful broods during a single summer.

Winter behavior, as seen in the loose feeding and roosting flocks containing both species, further shows the basic similarity in the requirements of both species. Differences in bill structure are postulated as mechanisms to reduce competition through different food. Molt is the same, not only in time of occurrence but in its pattern as well. Home ranges are established in which at least the older birds remain throughout the year. This was much more obvious in the case of the Cardinal than it was in the *Pyrrhuloxia*. Summer territories are established within this home range.

The territories of these two species are not mutually exclusive. On the contrary, they are often coincident. The amount of the study area utilized by the Cardinal for territories was 54.5 percent, while *Pyrrhuloxias* utilized 60 percent. Four Cardinal territories averaged 3.65 acres and had an average of 1.83 acres of mesquite woodland within each. Seven *Pyrrhuloxia* territories averaged 2.5 acres and contained an average of 1.2 acres of mesquite woodland. The placement of territories in the area was surprisingly similar, and were it not for the fact that there were about twice as many *Pyrrhuloxias* in the area, the territories may have been identical. Population pressure limits the size of the territories and suggests that spacing is one of the major functions of territory. Territories are established and maintained in the same manner, except that the Cardinal does not patrol the boundaries as does the *Pyrrhuloxia*. Food

is considered only a minor factor in the function of territoriality.

It has been postulated that the territories of these birds would be identical, as in fact several are, were it not for the difference in population pressure. Although no cooperation was noticed between the two, there could be some advantage gained by both occupying identical territories. Such advantages as predator warning, passive cooperation in advertisement, aid in food finding, and others would be of great value to the birds. Certain differences such as feeding habits, acceptance of more open nesting areas by *Pyrrhuloxias*, later start of singing and breeding in the *Pyrrhuloxia*, would allow these birds to use congruent territories without competition.

The tremendous similarity between the two species in question supports the hypothesis that they are congeneric. It is hard to believe that members of two separate genera cannot be reasonably well recognized in the field at all times, and that we cannot always tell with certainty the eggs, nests, and habits of these two species. Differences between the two may be explained by the fact that they have certainly reached a good species level. If we consider a genus as being a natural evolutionary group of similar species, and that the category is meaningful in stressing the similarities, rather than differences, it would then follow that we should consider these two as congeneric.

Plate 1. Field and mesquite woodland in study area.

Plate 2. Hedge row and Indian house in study area.

Plate 3. Mesquite woodland in summer.

Plate 4. Interior view of Mesquite woodland in summer.

Plate 5. Mesquite patch in winter in
which only *Pyrrhuloxia* nested.

Plate 6. Mesquite woodland in winter.

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