Also in June, 1964, L. Gerard Swartz and William J. Robertson, University of Alaska, found Red-wings at George Lake (63°48′ N, 144°26′ W), about 40 miles southeast of Delta Junction. Swartz and Robertson saw two males on 26 June, and one in the same area on 29 June; and they collected a pair (UA 2385, adult ♂; testes 5.9 × 4.7, 5.5 × 4.8 mm; and UA 2386, adult ♀; largest ovule less than 1 mm) in another nearby area on 17 July. This pair behaved as if a nest was nearby, but none was found.

Two other observations of Red-winged Blackbirds were made in the upper reaches of the Tanana Valley in June, 1964. On 1 June, Sidney Peyton of Fillmore, California, saw two male Red-wings in a small marsh near Scotty Creek (62°40′ N, 141°03′ W); and on 6 June, James A. Erickson, University of Alaska, James E. Hemming, U. S. Public Health Service Arctic Health Research Center, and Robert B. Weeden, Alaska Department of Fish and Game, observed a pair perched in a tall willow beside a marshy area in the same general area near Scotty Creek.

In addition to these interior Alaska records, Curtis H. Sherwood, recently of Juneau, collected an adult male of a pair of Red-winged Blackbirds (UA 2384; testes 6 × 7, 9 × 8 mm) seen feeding along the bank of a freshwater creek near Juneau on 30 May 1964. Sherwood had looked for Red-wings for some years in Juneau, but this was his first success. Richard M. Hurd, U. S. Forest Service Northern Forest Experiment Station, however, told me that he observed four female or immature Red-wings near the Juneau airport on 3 September 1962; he watched them for several minutes and was confident of his identification.

Finally, another straggler can be added to our Alaskan compilations on the basis of a sight record of a male Red-winged Blackbird seen on 17 September 1960 by Leonard M. Belson, then of a University of Alaska field party, at the mouth of Emmikroak Creek near Cape Thompson (68°08′ N, 165°56′ W). Belson reported that the red "epaulettes" of this black individual were strikingly visible as he watched it fluttering in some willow bushes 30 feet away.

Specimens from the upper Tanana Valley have been identified as *A. p. arctolegus*, the subspecies to be expected in the area.—BRINA KESSEL, *Department of Biological Sciences, University of Alaska, College, Alaska.*

Antiphonal dueting and evidence for auditory reaction time in the Orange-chinned Parakeet.—While analyzing the vocal repertoire of Orange-chinned Parakeets (*Brotogeris jugularis*), I observed and recorded two vocalizations of a kind not found with great regularity in birds. The vocalizations are termed "antiphonal duets" and are given by a pair in which male and female alternately utter distinct syllables, with considerable speed and precision. Audiospectrographic analysis of these duets provided a method whereby I could estimate the auditory reaction time of this species.

The nature of dueting.—A distinction should be made between the two most common types of bird vocalizations in which the male and female of an established or potential pair vocalize in a duet.

Calling in unison by two individuals may be termed *simultaneous singing* or *simultaneous dueting*. The latter I prefer in cases, such as with parrots, when vocalizations may bear little resemblance to "song" in the usual ornithological sense of the word. Simultaneous singing is described for many of the *Campylorhynchus* wrens (Selander, 1964: 188–197); a barbet, *Trachyphonus darnaudii* (Moreau and Moreau, 1937: 170; Osmaston, 1941: 310–311); the Barred Antshrike, *Thamnophilus doliatus* (Haverschmidt, 1947: 357–358); the ovenbird *Furnarius rufus* (Wetmore, 1926: 264); the Bar-tailed Trogon, *Heterotrogon vittatus* (Moreau and Moreau, 1939: 301); a cuckoo,

Centropus bengalensis (Young, 1942: 110–111); and certain sylviids of the genus *Bradypterus* (Moreau, 1941: 176–177; Vincent, 1935a: 512).

Antiphonal singing or *antiphonal dueting* is vocalizing by two individuals such that distinct or similar phrases or syllables are uttered alternately. Antiphonal singing occurs in the Marbled Wood Quail (*Odontophorus gujanensis*), cranes, and several species of owls (Armstrong, 1942: 134–136); in certain African bush-shrikes (Laniidae) (Thorpe, 1963: 774–776; Vincent, 1935b: 747); in the Gray-necked Wood Rail (*Aramides cajanea*) (Wetmore, 1965: 343); and in the Plain Wren, *Thryothorus* (= "*Thryophilus*") *modestus* and the Rufous-breasted Wren, *Thryothorus rutilis* (= "*Pheugopedius hyperythrus*") (Skutch, 1940: 295). Unrecorded in the literature is an observation by James D. Rising (pers. comm.) of antiphonal dueting by two Sulphur-bellied Flycatchers (*Myiodynastes luteiventris*) in August (probably a post-breeding pair). The first bird uttered the phrase "*wheet wheet tow*" (accented on the second syllable and downwardly inflected on the last), which was followed almost immediately by the phrase of the second bird, "*wheet wheet ta*" (accented on the second syllable and upwardly inflected on the last), which was again followed by the phrase of the first bird, and so on in an antiphonal fashion. The birds were perched about 20 to 25 feet apart and were clearly visible to each other.

Antiphonal dueting in the Orange-chinned Parakeet.—In *Brotogeris jugularis* I recorded two types of antiphonal duets. In the first, termed *high-intensity antiphonal dueting* (Figure 1, a), each member of a pair gave characteristic chirps. The louder and more highly pitched (*chee*) were uttered by the male; they were mainly at frequencies of 2.5–7.0 kc/sec, were each approximately 0.16–0.70 second in duration, and were given at about 0.35 second intervals. Alternating between chirps of the male were syllables by the female (*cher*). These were approximately 0.15–0.16 second in duration, were less loud than those of the male, and were mainly at frequencies of 2.0–5.0 kc/sec. As given by both birds, the resulting vocalization is a rapid, precisely alternating *chee-cher-chee-cher-chee-cher*, lasting from two to five seconds. Several such choruses were usually given in sequence. The duet is somewhat melodius and surprisingly loud and piercing to the human ear at close range.

For the most part, males gave the first note and females the last note of a duet. Thus, initiation and termination of high-intensity duets seemed to depend on the male, although choruses given later in a sequence were sometimes initiated by the female. Males frequently solicited their mates to join in the duet by giving a single chirp, one or more times, not unlike the syllables of the male described above. With the exception of such solicitation chirps, I never heard a bird give its portion of the duet without the vocal complement being given by its mate.

Vocalizing birds sit side by side, or, if moving, they move together. The male calls with bill wide open and body erect, often rhythmically moving the head up and down. The female calls with bill partly open and is usually not as erect in posture as the male. A female may also keep her head in motion, often alternating the position of her head with that of her partner.

A second vocal duet in which male and female alternate, even more rapidly than in the first, I have called *medium-intensity antiphonal dueting* (Figure 1, b). Here again males gave the louder and more highly pitched chirps. Frequencies were mainly 2.0–6.0 kc/sec, and the chirps were each about 0.10 second in duration. About 0.10 second separated male syllables. Notes of the female were usually 1.5–3.0 kc/sec in frequency and about 0.08 second in duration. The birds call with bills almost closed, lending a muffled quality to the duet, which is not as loud as the high-intensity form. The male may give at least three slightly different syllables (see Figure 1, b). These

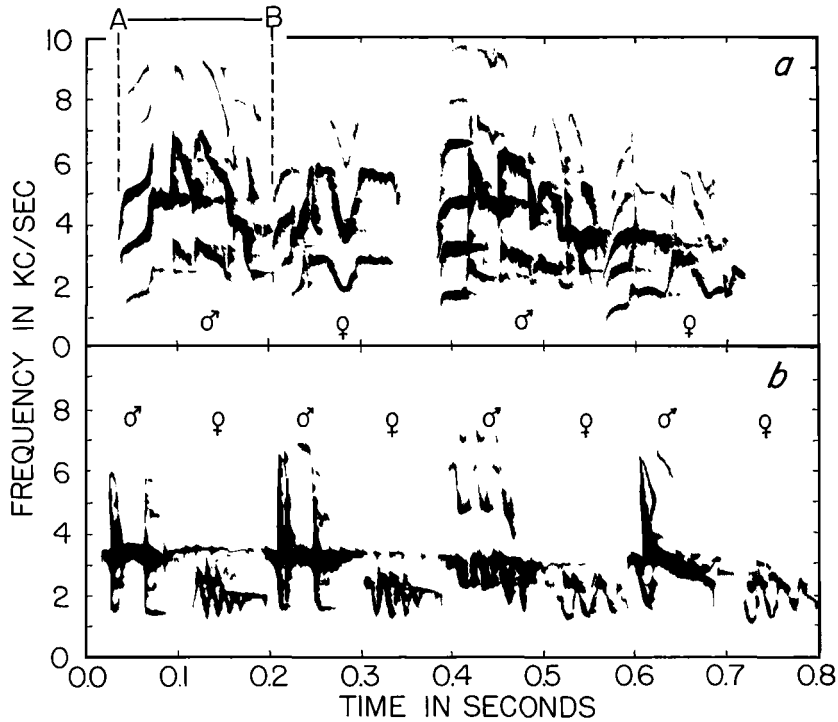

Figure 1. Drawings of audiospectrograms of (a) high-intensity antiphonal duet, and (b) medium-intensity antiphonal duet. Distance A-B is time between the beginning of the first syllable (given by a male) and the beginning of the second syllable (given by a female) of a single chorus.

variations were often regularly repeated, giving the over-all vocalization a character of rising and falling intensity. Either member of the pair may initiate the call and, when vocalizing, both birds may sway up and down or from side to side on the perch.

The time intervals of both duets were remarkably precise and constant. This precision seems not to be achieved without a certain amount of practice. In a flock of 28 first-year parakeets obtained in December, dueting at first was infrequent but, when given, the syllables were unusually long and the antiphonal timing imperfect. (Prior to December the birds had been held in quarantine for about two months in a single cage at the San Diego Zoo, San Diego, California.) Unfortunately, no recordings were made of the vocalizations in December and audiospectrographic comparison with later and presumably definitive calls was not possible. Dueting occurred more frequently and with greater precision in January, at which time pair bonds were strengthened as judged by behavioral changes. Also, in January, two pairs began nest excavations in artificial termitaria. By the end of February the vocalizations were seemingly mastered by the two nesting pairs and one other pair in which the members were highly attentive to each other. The most precise duets I recorded were those given by two birds that had been together as a pair for about two years and had attempted nesting once in that time.

In Orange-chinned Parakeets both high- and medium-intensity antiphonal duets were performed by paired birds in an aggressive or a highly excited state. Duets were commonly associated with certain components of aggressive and annoyance behavior, such as rushing or pecking at an opponent; other vocalizations which are generally indicative of annoyance, such as high-intensity squawking, may precede a duet or occur between choruses. I consider dueting in these birds to be "vocal mobbing" since it is frequently heard as a pair chases one or more intruding parakeets from a nest or favored roost, or during prolonged or intense aggressive encounters between two pairs or two small groups of birds in which some of the members are strongly paired. Dueting was directed toward me when I tampered with nests or in some other way excited the birds. Duets have also been directed toward Orange-fronted Parakeets (*Aratinga canicularis*) and Aztec Parakeets (*Aratinga astec*) when these were introduced into cages housing Orange-chinned Parakeets. The observed instances of antiphonal dueting suggest that any actual or potential predator or "competitor" in the vicinity of a nest may elicit the call from paired birds. The vocalization was also heard when pairs were maneuvering for favored roosts; however, in captivity these roosts were within six feet of respective nests and it was impossible to ascertain whether aggressive encounters were concerned with nests, roosts, or both.

The value of antiphonal dueting in Orange-chinned Parakeets apparently lies in permitting a pair to indicate (or communicate) the threat of aggression to intruding parakeets. In cases involving a predator the duets may serve as a harassment, calling attention to and thus revealing the source of danger, in addition to indicating aggressive tendencies in the dueting birds.

In many other species of birds simultaneous or antiphonal duets may serve as part of a courtship display, assist in the maintenance of a pair bond, or serve in maintaining contact when the members of a pair are out of one another's sight. The literature indicates that both antiphonal and simultaneous singing are most characteristic of tropical or subtropical birds, which are normally secretive or frequent habitats of dense scrub growth or jungle. Thorpe (1961: 50) suggests that such habitats may hinder mutual recognition and maintenance of contact by visual display, and thus auditory display may accompany or take the place of visual display. Such is clearly not the case with *B. jugularis* since the calls were given only in a context of aggression and pair members have never given duets when separated.

Discussions concerning the evolution of antiphonal dueting in the Orange-chinned Parakeet await further study of the genus *Brotogeris* in the wild. However, certain other parts of the vocal repertoire of *B. jugularis* suggest precursors of the duets or, at least, the vocal potential on which selective forces might operate. Certain chirps, higher in frequency and intensity and longer than the syllables of a male in high-intensity antiphonal dueting, are given singly by both sexes when a potential predator approaches, and apparently serve as alert calls for a flock. In addition, pair and flock members alike, when annoyed, may simultaneously utter repetitive, high-intensity squawks. These are equivalent to simultaneous duets, in this case with squawks rather than brief melodious syllables. It is possible then that with incorporation of chirp-like syllables in threat situations pairs developed a rapid, antiphonal pattern which indicated or communicated a state of annoyance, hence the threat of aggression, to others of the species. Pairs developing an antiphonal duet may have fared better in maneuvering for nest sites. Dueting pairs may also have had a reproductive advantage in situations involving predators, and those involving other species of parakeets with which they may share the same food supply or nesting sites. Such speculations obvi-

ously assume conditions under which interspecific and intraspecific competition are operative.

Estimation of auditory reaction time.—From listening to high-intensity antiphonal duets at slow tape speeds and examining audiospectrograms of the beginning of several choruses, it was apparent that the duets are initiated by the first syllable of the first bird and that no prior vocal warning occurs. Likewise, no prior behavioral warning has been observed. Thus, bird A begins the duet with a single chirp, bird B joins in with its first note and the second syllable of the chorus, bird A calls again, and the call continues in the usual tempo. The time it takes for bird B to respond depends on the duration of the first syllable (that of A) and the auditory reaction time of B. Once the duet is underway the constant rhythm is probably the primary factor in maintaining the time intervals. It is doubtful if opening of the bill by A serves as a visual stimulus for B since during an aggressive encounter the birds may open the bill for reasons other than dueting, such as gaping at opponents and giving other vocalizations. The time between the beginning of the first two syllables of a duet (Figure 1, a; A–B) may approach the shortest time in which a bird can respond, and measurement of this time interval could thus give an estimation of minimal auditory reaction time in Orange-chinned Parakeets.

The time in milliseconds (msec) between the start of the first and second syllables of 14 high-intensity duets was as follows: 165, 165, 170, 150, 165, 175, 175, 155, 160, 180, 170, 180, 160, 130. The first seven listed were initiated by the male, the last seven by the female.

Time sequences were measured linearly on audiospectrograms, produced by playing master tapes (originally recorded at 7.5 in/sec) at one-half speed into a Sonagraph 662-A sound spectrograph. A period of at least two seconds of silence was allowed before the first note; occasionally, squawking immediately preceded the duet but appeared to have no effect on the reaction time. Recordings from which these measurements were taken were of two birds that were experienced in dueting, having been together for at least two years. For this pair I recorded a mean auditory reaction time of 164 msec, with a standard deviation (S.D.) of 13.3 msec. Statistical comparison of seven choruses initiated by the male and seven by the female revealed no significant difference (.05 level) between the sexes in auditory reaction time.

In using high-intensity antiphonal dueting to estimate auditory reaction time there is no assurance that a minimum reaction time is actually involved. The calculated reaction time of 164 msec may be high since it is not known to what extent the duration of the first syllable affects the response of the second bird. The calculation is based on the assumption that bird B gauges its response from the beginning of the first syllable given by bird A. If it is also assumed that bird B responds with as little delay as possible, then a minimum reaction time may be indicated by consideration of medium-intensity antiphonal duets. In these duets the time between the beginning of the syllable of A and that of B was about 100 msec when well into the chorus. If bird B is capable of responding in 100 msec or less, then at the outset of medium-intensity antiphonal duets it would be expected that bird B would respond immediately after the first syllable of A. Such was not the case, however, as at the outset of these duets, bird B, male or female, never responded immediately after the first syllable of A; rather bird A uttered two or more syllables before bird B uttered its first. Therefore, although the calculated auditory reaction time of 164 msec may be slightly higher than minimal auditory reaction time, it is doubtful that the minimum is less than 100 msec.

Thorpe (1963: 774–776) has acquired data on the auditory reaction time of the

Black-headed Gonolek (*Laniarius erythrogaster*) by a similar study of antiphonal dueting. In *L. erythrogaster* the call apparently serves to keep the male and female of an established pair in contact when they cannot see each other. Measuring the time between the start of the first and second notes of eight consecutive duets of a pair gave a mean reaction time of 144 msec and a S.D. of 12.6 msec. Since the dueting birds were apart, a correction for the time it would take the sound of bird A to travel to bird B over a distance of 10 feet (which Thorpe thinks is minimal) reduces the mean to 135 msec and the over-all low to 116 msec. For *L. barbarus*, Grimes (1965: 103) records a mean reaction time of 118 msec with a S.D. of 30 msec.

Studies of these vocalizations and other natural phenomena in which minimal reaction times seem to be approached or intrinsically involved will permit comparisons with more rigorously controlled studies in the laboratory, from which a more exact picture of the powers of the avian nervous system in the matter of time discrimination and auditory reaction time may be obtained.

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