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The vocabulary of the Great Tit

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(Plates 59-61)

INTRODUCTION

THE VOCABULARY of the Great Tit (*Parus major*) is notorious for its variety. Nicholson (1936) remarked that "a proper description of the Great Tit's language would almost require a book to itself, for no other British bird uses such a wide variety of different notes". *The Handbook of British Birds* refers to the need for an adequate analysis. No such analysis has yet been published, though Hinde (1952) discussed some calls and song.

Any serious study of a bird's vocabulary requires the use of recordings which can be made available to other workers, so that they are at least agreed on the exact call whose significance they may wish to question or discuss. The object of this paper, in which almost all the calls and songs discussed have been tape-recorded,* is to suggest a possible classification of the Great Tit vocabulary—one based chiefly on the types of behaviour with which certain elements in the vocabulary are associated.

This approach to the analysis of the vocabulary has naturally led me to consult the considerable literature relating to Passerine behaviour. However, for reasons of space and of the limitations of my study to date, I have included very few references. Much of the literature results from the detailed studies of professional ethologists into individual species and families, to which it seems useless to refer unless one is in a position to contribute something useful to the discussion of points of theoretical interest.

*Copies of recordings made during the present study will be deposited with the Library of Recorded Animal Sounds of the Committee for Biological Acoustics

BRITISH BIRDS

METHOD AND LOCALITIES OF STUDY

For the past four years, I have studied the Great Tit's voice and behaviour, using the following methods:

1. The vocabulary of known and colour-ringed birds, whose daily activities I have watched closely for lengthy periods, has been recorded.*

2. The hand-rearing and subsequent keeping of birds free-flying within a house and aviary. (In the case of one bird, it was entirely free-flying during the last weeks before its life was ended by an accident; this bird, a male, was paired to me and therefore followed me round the garden and on short walks.)

3. The vocabulary used by birds in areas in which it was not possible to record was transcribed in a notation devised by my friend Rosemary E. Jellis, who also made the musical analysis of the songs.† During field observations where recording was impracticable, and in the work of analysing the several hundred recordings, it was invaluable to have the continual help of a colleague concentrating exclusively on the nature of the sounds heard.

4. Certain of the calls recorded, and the entire song repertoire of two males, have been submitted to spectrographic analysis.

Of those birds whose vocabulary I recorded, one pair of adults nesting in the garden of a research institute at Hampstead, and two of their fledglings, were hand-tamed and performed most of their activities very close to me—in the case of the juveniles while actually perched on or hopping about on me. Another pair was recorded on a Yorkshire farm during one breeding season. The remainder of my recordings of wild-living tits have been made in a Middlesex garden of one-third of an acre, on the edge of a golf course which includes considerable stretches of mature oak woodland and thorn scrub. The garden itself includes a strip of mixed woodland fronting the house. Several of the neighbouring gardens (each including a strip of woodland) have been open to me for constant observation, thus providing opportunities for keeping track of the activities of seven pairs of Great Tits.

*Throughout this paper the use of the word "record" indicates an electric recording available as evidence of what sound the bird uttered.

†This system of notation had been devised before she knew of North's valuable paper on "Transcribing bird song" (1950). She is in firm agreement with him on the importance of standard musical notation combined with some form of phonetic indication, where appropriate, for the accurate transcription of songs and calls. Her own field notation, however, differs somewhat from his and omits the use of tonic sol-fa symbols.

GREAT TIT VOCABULARY

At fledging time, some young of a number of local broods followed their parents to our garden and later spent a good part of the late June, July, August and September days in it. This enabled me to observe juvenile voice and behaviour more closely than is usually possible in the dense scrub at wood edges where so many tit youngsters often congregate. This close observation of comparatively tame but wild-living youngsters served as a necessary check on my observations of the hand-reared birds.

Continual observations were also made, and calls noted, in an area of approximately 75 acres which includes the golf course already referred to and some roughish pasture lands divided by thorn hedges and numerous well grown oak, ash and elm trees. Apart from the two localities mentioned above, field observations were made, and calls and songs transcribed, in a few other country areas, chiefly in Middlesex, north-east Scotland and Yorkshire.

CHARACTER OF THE GREAT TIT

It is hardly necessary to give any detailed description of the life and habits of so familiar a bird. But there are three aspects of its character, so clearly related to the large vocabulary it uses, that should be mentioned. The Great Tit is extremely active, very social and highly excitable. As Newton remarked in his *Dictionary of Birds*, "Few birds are more restless in disposition, and if 'irritability' is the test of high organisation, as one systematist asserts, the Paridae should stand very near the top of the list." This "irritability" of the *Parus* temperament is certainly one of the factors which must be taken into account when attempting to understand the significance of the variety of calls *Parus major* is capable of producing within a very short space of time. One cannot watch Great Tits for very long before realising that it is almost impossible for a member of the species—particularly a male—to remain silent for long. It goes about its daily round in a nearly continuous state of exclamation, sometimes delivered loud and clear, occasionally almost explosive, often *sotto voce*. Indeed, the silence in a house recently deprived of the presence of a resident Great Tit is almost intolerable.

CHARACTER OF VOICE AND VOCABULARY

(This section has been written jointly by the author and R. E. Jellis)

To the human ear, the chief characteristics of the Great Tit's voice and vocabulary, considered in musical terms, are: that the bird produces musical notes of a more or less definite pitch and duration; that it uses the most common elements in the diatonic scale, the full tone and the intervals of the major and minor thirds, fourths, fifths and octaves; and that with these simple melodic elements, individual birds build

up a considerable repertoire of songs and calls by changes of tempo and rhythm.

There are, however, other elements in the vocabulary which must be described as noises rather than musical sounds—these are, as it were, the ejaculated, as opposed to the sung, elements.

The distinction between the two types of sounds is clearly evident when one is trying to make a notation for the vocabulary. The musical sounds present no great problems; they can all be written in ordinary musical notation with the addition of a few signs to denote certain tone-qualities. For the non-musical sounds, however, one must devise a set of serviceable symbols chosen merely for ease and speed of writing.

While we have said above that many of the calls, and all the songs, are built from whole tones and the most common intervals of the diatonic scale, we do not wish to imply that a given call or song is always immediately recognisable as, say, a phrase consisting of major thirds or the common chord. As with our own musical phrases when played at a very high speed, the shape of the phrase and an impression of the intervals used are immediately apparent; but it is sometimes necessary to play it more slowly to make an accurate analysis of the rhythm, tempo and intervals. This is a problem in which the use of the tape-recorder is invaluable. One can play the phrase at half the speed at which it was recorded, thus getting an exact notation. (By halving the playing speed, of course, the phrase is heard an octave lower—making it easier to check the exact pitch by reference to a piano or wind instrument.)

ANALYSIS OF THE VOCABULARY

Method

In analysing a complex vocabulary, one fruitful method is to follow the course of its development from the juvenile stage onward. Valuable clues to the significance of certain calls, or groups of calls, may be found by discovering whether they are present or absent in the vocabulary of juveniles and of mature birds of both sexes throughout the behaviour cycle or at any given point in it.

A. Begging notes

During most of its time as a nestling and throughout the period after fledging when following its parents for food, the young Great Tit utters begging cries which have been rendered as *tsee-tsee-tsee-tsee-tsee* (*The Handbook*) and *zicker-zicker-zicker-zid* or *zi-zi-zi-zi-zi-zi-zi-zi-zi-zi* (Hinde 1952*). Unlike Hinde, I find the begging notes of the Great

*This particular work is referred to regularly from now on and, for ease of reading, the conventional repetition of the year or "*op. cit.*" has been discarded; all references to Hinde in the remainder of this paper are to his 1952 publication.

Tit completely different from those of the Blue Tit (*P. caeruleus*). The pitch variation of the Blue is nearly always such as to end in one or more falling notes whereas the Great Tit almost invariably rises. This is a useful difference when one is trying to locate tit broods in a wood.

The begging calls of different broods of Great Tits are often dissimilar in tone-quality, as are the voices of their respective parents, and individuals among broods vary in pitch. (I have some evidence which suggests that the pitch variation might be indicative of the sex of the nestling, the higher voices in one brood being those of the males and the lower those of the females.)

The proximity of the parent and the competing cries of other youngsters both serve to make the begging cries more intense and to rise more sharply in pitch. As with so many other species, the begging cries are accompanied by wing shivering.

B. *Contact note*

As soon as the young tit fledges, it makes a call which I used to consider was merely a different version of the begging notes—usually three rather reedy notes of the same pitch. But closer observation of the circumstances in which it is made has convinced me that it should be regarded as the first stage in the development of the adult call note *pee* (see under). Characteristically, the youngster utters a group of three of these notes when temporarily isolated from its parents or companions. When watching a brood emerge from their nest site, one hears first one and then another utter these rather plaintive notes after making their first and often rather uncertain landings. And when a party of fledglings is on the move with its parents one can always tell when one member has got left behind—and its location—from these notes delivered by the isolated youngster.

The following instance may serve to point the difference between begging notes and this call. I happened to be in another room when one of a pair of nestlings I was hand-rearing fledged from their nest box. It was these notes, uttered by the fledged youngster, that brought me to the room to find it perched on a chair. On my approach it changed to begging: contact had been re-established with its adopted parent.

C. *Juvenile "warble"*

The next stage in the development of the young Great Tit's voice is both interesting and exciting to hear. As it begins to be slightly independent of its parents—a stage which occurs between seven and fourteen days after leaving the nest—there are changes in voice to accompany the changes in behaviour.

The young bird is mastering its environment to some degree, finding a number of caterpillars and insects for itself, hanging upside down quite competently in the process. Along with one or more members of the brood, it is now more liable to be left for some time in the "nursery" thickets where young tits are taken, until one or both parents return from a private foraging expedition or "quiet time" and collect the brood together again to move on elsewhere. It is during these stationary spells that one first hears the beginnings of a most attractive warbling utterance. As the parent flies away the youngster has probably been begging at intensity and it may continue a little, interrupting itself to peck at a leaf or twig. Then it gives the first one or two notes of begging and finds itself uttering another note, higher in pitch; the effect is somewhat similar to the breaking of a boy's voice at puberty—except that the "cracking" results in a higher note and not a lower. Having hit this note, the young tit goes off into a little *glissando* passage. This appears to intrigue it and the process is repeated. From now on, the youngster does more and more of this free "warbling", shaping the passages, as it were, more to its own satisfaction.

This random, experimental use of the voice appears to be associated with all kinds of exploratory activity, such as examining holes and cracks, tapping at different kinds of surfaces, pulling at leaves or chasing humble bees. It also occurs between little bouts of preening or when the bird is sitting still. I have never heard it from a youngster who appeared to be food-searching in earnest.

For example, a youngster, about three and a half weeks fledged, used constantly to take cheese and nuts from a little basket attached to a pergola. When it wanted to feed, it merely went straight in and out of the small entrance hole. Then, if it made any sound at all, it would merely utter two or three begging notes. But at other times, whether or not there was still food in the basket, it would play about, tapping the closed end of the basket from outside, pecking at the gaps in the basket-work, or going in and tapping about inside, peering out from time to time, and so on. This behaviour, very engaging to watch, was accompanied by little bursts of warble.

Since the warbling passages are *pianissimo*, often carrying only for a distance of three yards or so, they would be difficult to hear from a bird in, say, a bramble thicket, unless one were already "tuned in" to the sound. Without watching hundreds of broods in garden and woodland conditions, it would be difficult to prove the point, but I imagine that since it is entirely a leisure activity the amount any one youngster will "warble" will depend on how easily it is getting its food and on its general sense of well being. My own hand-reared birds "warbled" a great deal; so did the pair of hand-tamed youngsters in the Hamp-

stead garden and the youngsters around my present garden, both places where the food supply is liberally topped up by human offerings.

The juvenile "warbling" is heard from youngsters of both sexes. But comparing the recordings from my hand-reared birds (whose sex was, of course, subsequently known) and from listening to the garden and woodland birds (where there was, however, no subsequent check on sex) I believe that there may be a difference in the "warbling" of young males and females. Briefly, this could be described as giving the aural impression of having a more definite pattern and a greater range of musical material in the case of young males.

During "warbling" the bill is normally closed, or nearly so, as it is in the adult "whispered quiet song" (see section D). When it reaches peaks of intensity, however, the bill is slightly opened and the wings may be shivered.

I have heard a very similar "warbling" from many young Blue Tits—and recorded it from a hand-reared Blue Tit—and also heard it from young Coal Tits (*P. ater*). The circumstances in which it was delivered were similar to those mentioned above.

This "warbling" of young tits is much stimulated by other sounds; all those I have watched have shown the most intense interest in any sounds with high frequency components. Indeed, I could almost guarantee to get my hand-reared birds warbling at the first hearing of any complex, high-pitched noise; trilled passages in the highest register of the piano, the higher woodwind acrobatics in orchestral music, the continual "squinking" of recording tape running on a metal spool, or rain falling hard on a slate roof; also the noise of an ancient geyser and the sizzling of frying bacon. Apart from rain on a roof, these noises are not usually heard by young birds in the wild, but those anywhere in earshot of the mechanical din of modern civilisation are certainly affected by the high frequency components of the devastating noises we have come to accept as inevitable. The hand-tamed juveniles in the Hampstead garden were sent into frenzies of warbling by the whine of a circular saw and the second of my hand-reared birds, when in his aviary, was fascinated by the sound of a peculiarly vicious electric hedge-cutter operating nearby. The songs of other birds such as the Willow Warbler (*Phylloscopus trochilus*), the Wren (*Troglodytes troglodytes*) and the Robin (*Erithacus rubecula*) also appear to be a stimulus, though the young tits I heard in the wild did not appear to try and mimic the songs—or else they were not very good mimics. My hand-reared male, after the moult, could produce passable Robin imitations, but our resident male Robin was far better at mocking the tit.

D. "Quiet song", "whispered" and "intense"

Apart from the random warbling of juveniles, there are two other types

of "quiet song" in the Great Tit vocabulary, normally delivered when the bird is alone. (I use the term "quiet song" merely to imply that these utterances are soft and of a generally musical nature; not that they in any way resemble true song.)

The first, which I call "whispered song", is very similar to the random warble of juveniles and I have heard it from both males and females, though more frequently from the former. The female version is more squeaky in tone-quality, more *glissando* and less mellifluous than the male.

"Whispered song" is only audible at a few yards—a maximum of ten in very quiet conditions. I have heard it most often on mild days from February to the start of breeding, and again during the time after the young have fledged until the moult. Typically, this "whispered song", like the juvenile warble, always occurs in periods of relaxation and is delivered in cover.

Since quiet song of this kind is only audible at close range, it would be rash to infer that it is absent from the vocabulary at any time of year just because one had not heard it. But common sense would suggest that, since it appears to be connected with a relaxed state of well-being, the seasons during which the bird will indulge in "whispered song" will be those when food-finding is easy and other stresses are absent.

The second type of quiet song is an utterance which I call the "intense", because of its character and the manner in which it is delivered. It consists of phrases of high-pitched notes, ranging over a fifth or more, heavily stressed and glided into one another. A succession of phrases may continue for as long as thirty seconds without a pause and the whole utterance may go on for several minutes. During it, the bird—though, as far as I have been able to judge, invariably alone—appears to be in a condition of considerable excitement, the wings being shivered rapidly, the stance crouching, the head somewhat bowed and the mandibles slightly parted: all features strikingly similar to the courtship feeding and pre-copulatory display, in which, however, the vocal utterance is different (see section R3).

I have not heard "intense" quiet song from a known female. Of my hand-reared birds, it was only the male who used it, starting in the latter stage of his juvenile days. I have heard it from a few juveniles in the wild, shortly before the moult, but have not known their sex. The one wild juvenile whose behaviour at the relevant period I was able to watch closely was in an extremely aggressive state, threatening and attacking both adults and other juveniles.

In the case of adult males, the circumstances, when known, were: (a) frequently from unmated males, apparently in search of a mate, most often from February onwards; (b) occasionally from mated

birds at the start of the breeding season; and (c) frequently from mated birds towards the end of the breeding season and towards the end of and immediately after the moult. However, since this type of quiet song is also only audible at a few yards, one would need a far longer period of study to be sure of the exact circumstances in which it is delivered. From my observations so far, I suggest that it is associated with a degree of sexual excitement which has no other outlet.

I do not feel in a position to judge whether either of these two types of quiet song can be regarded as sub-song, for the exact definition of the nature and significance of sub-song remains a matter requiring, as Thorpe (1956) and Thorpe and Pilcher (1958) have emphasised, a great deal more research. I have therefore merely given each type a provisional name which, I hope, will help field ornithologists and others interested to recognise the respective utterances.

E. "Hawk" alarm call

The "hawk" alarm call, described by Hinde as a high-pitched and trilling *tsee-ee-ee-ee*, is given by all Great Tits in response to a possible predator flying overhead. My hand-reared nestlings uttered it if one inadvertently flicked a piece of material over them. Newly fledged youngsters use the call whether or not their parents are present. The *tsee-ee-ee-ee* call, as Hinde states, is not only given in response to the sight of a tit predator; any largish bird flying overhead, such as a pigeon or a gull, may evoke the *tsee-ee-ee-ee* and its accompanying behaviour: either the tit flies into cover or it remains in the same place—in both instances crouching with head retracted into the shoulders, crest flattened and bill pointed upwards. My hand-reared birds gave the *tsee-ee-ee-ee* call at the sight of aeroplanes and I have heard wild youngsters and adults apparently do so, but with birds in the wild it is, of course, much more difficult to be sure that the aeroplane is the stimulus.

F. Churring

Before it is independent of its parents, the young tit develops the churring notes written as *chich-ich-ich-ich-ich* in *The Handbook*. The churring utterances of juveniles when they are fully independent, and of adult males and females, are extremely varied—chiefly by differing prefixes and the tone-quality and duration of the churring itself. The variations are so many as to make classification difficult, but there are at least six varieties comparatively easy to distinguish, each associated with different situations and forms of behaviour.

1. The true "alarm" and "scold" churring is always used at the approach of possible ground predators, such as cats and dogs, and at

perched Tawny Owls (*Strix aluco*), Cuckoos (*Cuculus canorus*), Magpies (*Pica pica*) and Jays (*Garrulus glandarius*). It is often preceded by a series of "pits" and "chits" or similar sounds with a noise component; thereafter each churr is prefixed by these sounds. But as these utterances grow more intense, the prefix is often dropped and the churring becomes extremely rough in tone-quality and prolonged in duration. If there are a number of tits scattered through a garden, one can follow the route of a prowling cat by the unprefixd throaty churrings of the tits near whom it is passing. As on all occasions which cause anger and alarm, the crest is erected during this type of churring. Both members of a breeding pair, particularly the male, will use it at a human being, even one they are unafraid of in other situations, when he or she comes near the nest or newly-fledged brood. Nestlings and newly fledged birds are silenced by scold-churring. My observations indicate that young birds appear to learn from older birds to churr at cats and humans.

A brood of fledglings, visiting the garden with their parents, ignored my close approach for a period of three to four days. Meanwhile their parents were churring away. At the end of that time, the youngsters greeted my approach by churring. Similarly, a hand-reared bird sat, watchful but silent, in the outside aviary while a cat prowled by. Meanwhile, the outside tits were churring. This happened—to my knowledge—two or three times on three successive days. By the fourth day the youngster was churring away at the cat. The young tit begins by a rough unpractised churring and then adds the prefixes.

2. The second variety of churring is used in several types of situation—all of which may be characterised as "exciting", "tricky", "annoying" or "frustrating". Though it can be somewhat similar to the mildest form of "scold" churring, the notes are not very long in duration, nor rough in quality; they may be prefixed by *tsee*, *pee* or *pit* or *chit*, but these are never delivered with any great intensity. A typical situation in which this type of churring is used is when a Great Tit falls from too light a twig while imitating Blue Tit acrobatics on, say, a silver birch. It is this variant of churring (without prefix) which is usually the first heard from a hand-reared bird and often from wild fledglings; characteristically when they make their first clumsy attempts at hanging upside down or find themselves hanging upside down and just succeed in not falling off. The same variety of churring is also used by adults when an accustomed food supply is not forthcoming; my garden birds will churr in this way if the kitchen windows are closed so that they cannot get at the jar of nuts kept for them on the inside sill. Males and females use this variety when foraging and investigating nesting and roosting holes. Both sexes use it at the

young towards the end of the fledgling period when the youngsters are still pursuing them relentlessly for food. And a male leading the brood to roost will churr in this way at the "zickering" youngsters who keep holding up proceedings.

3. The third variety of churring has a different type of prefix, almost impossible to translate except as a "squawk". (The squawk is used by itself also and always appears to indicate a mixture of fear and aggression. It is accompanied by the wings-raised threat posture.) The squawk-churring is heard a lot from young birds when, towards the end of the fledgling period, they start to chase each other away from food and favourite perches and begin to use the wings-raised threat posture in so doing. I have heard squawk-churring from adult females apparently resenting the too close approach of their mates. I have never heard it or the squawk from an adult male.

4. The fourth variety of churring is used between paired adults, notably when one is thwarted of the company of the other. Two or three short, separated churring notes are prefixed by two *pee* notes. Of all the varieties used, this is the easiest churring utterance (to human ears) to distinguish as uttered by a given individual. When my hand-reared male followed me round the garden I usually knew where he was by his "pee-churrs", even when two other males and females were "pee-churring" at the same time. Males use this "pee-churring" (among other calls) when apparently trying to entice the female out of the nest-hole after she has settled in for the night (or the roost-hole in winter) or when they themselves are refused entrance.

5. The fifth variety of churring is usually prefixed by "pits", "chits" or "spicks", or occasionally, in the case of males, by "tinks". The churring is often a lengthy roll (but it differs greatly in length), much lighter in tone-quality than scolding-churring and higher in pitch. It is used during reproductive fighting by both males and females.*

6. "Chatter-churring" is a light (in tone-quality) and stylised version of scolding-churring. It sounds rather like a miniature version of a Magpie's *chatchatchatchatchack* (this is by no means the only time when Great Tits succeed in convincing one of corvine affinities!). Chatter-churring is used by both males and females and, when I have known the circumstances, the individuals were always paired and usually appeared to have lost contact with their mates. However, I

*Following the suggestion of Hinde, I use the term "reproductive fighting" to denote fighting which "serves to secure objects or situations which are indispensable for reproduction"—i.e. the term covers fighting in which the defence of, or the acquisition of, territory or a mate are involved. Normally, reproductive fighting in Great Tits is intra-specific but it may be inter-specific (with other Paridae) in cases of skirmishes over nest sites.

have heard it when the pair have been together and on these occasions it has followed a skirmish with intruders into the territory.

Although I have tried to indicate the characteristic situations in which the various churring utterances are heard, it is important to stress the fact that an individual passes very easily from one to another variety. Thus, within a few minutes one might hear a male awaiting the emergence of his mate from the nest site first thing in the morning use the first, second, fourth and fifth varieties of those I have listed. If one was in a position to see all that was going on one would realise that the bird had scolded at a passing Grey Squirrel (*Sciurus carolinensis*), discovered that a favourite perch had been blown down overnight, failed to entice the female from the nest site, and seen off an intruding Great Tit.

G. *Non-musical sounds*

Various of the non-musical sounds already mentioned are to be heard from juveniles about the same time as warbling starts. The sounds are extremely difficult to transcribe; for convenience, and to give some idea of the sound quality, I render four of them as *pit*, *chit*, *spick* and *squink* (a spectrogram of a call in which *spick* is one of the elements is shown in plate 61b). These sounds, and some others very similar in character, are heard most commonly when juveniles, and adult males and females, are foraging, or during intra- and inter-specific fighting. One can only say that, used by themselves, they appear to be a series of ejaculations uttered by the bird with different degrees of intensity dependent both on its own internal state and the external circumstances. They form, as it were, a running commentary on the activity it is conducting, whether it be food searching, hole examining, bathing or fighting. Except when combined with other musical notes, or with churring, they are audible only at close range.

The non-musical sounds include the "distress" or "injury" call or shriek—very similar to that of some other species of small Passerines. The only occasions on which I have heard it were once when I accidentally injured one of my hand-reared birds, and occasionally during fighting among wild birds, when one has apparently been hurt.

One non-musical sound which will be familiar to those who have had occasion to make close observations of nesting behaviour is the explosive hiss mentioned in *The Handbook* as used by an incubating bird disturbed on the nest. The hiss is undoubtedly an indication of agitation. Hinde describes a very elaborate display made by a male Great Tit at a Grey Squirrel in its drey, during which the bird hissed continuously. I have heard the hiss preceding the *tssee-ee-ee-ee* alarm call, given by birds disturbed at their roosts and preceding the scold-churring. In all cases there appears to be an element of surprise

inducing the agitation. On the nest or at roost the hiss is often accompanied by wing-flaps.

H. Tsee, pee, tink

1. At the same time as the young Great Tit begins to lead an independent existence—foraging on its own account—it also begins to utter the adult notes *tsee* (*The Handbook*) and *pee*. The *tsee* is dulcet and high-pitched, the notes being delivered in a rapid sequence. The *pee* notes are subject to great variation within the vocabulary of one individual, but I use the rendering for all varieties since one cannot devise verbal renderings which would represent the variations that are distinguishable by ear, can be transcribed in musical notation and are indicated by spectrographic analysis. In contrast to the *tsee* note, with which they are often combined, *pee* notes may vary in pitch but are more commonly about an octave lower when used as a succession of single notes. Their characteristic quality I have tried to convey in the rendering *pee*, the labial consonant combined with “ee” suggesting the open, carrying sound typical of the notes. From the same bird some *pee* notes are very dulcet, others are louder and coarser, and others still are noticeably short in duration and staccato. (See plate 59 for spectrograms of *tsee*, a dulcet *pee* and the loudest form of *pee*.)

Among adults, some of the male variants of the *pee* notes can carry over considerable distances (150 yards in favourable acoustic conditions), though none has the ringing quality of *tink* (see below); the female versions, like those of juveniles, are usually softer.

When used simply as a succession of notes, as opposed to a call in which the notes are grouped in a definite and repeated pattern of pitch and rhythm, the *pee* notes are usually of approximately equal duration, evenly spaced in time and more or less level in pitch.

2. *Tsee* and the various *pee* notes are used in many calls, which may be most usefully divided into:

GROUP A. With one exception, those which are composed solely of *tsee* or the *pee* variants. These calls are all associated with situations in which there is no obvious aggressive or self-assertive display and are heard from juveniles (after independence) and adults of both sexes. In these calls the notes are varied in pitch and may be unequal in duration and unevenly spaced in time. Four common calls are:

(i) Two notes of approximately equal duration and emphasis, but with the second note lower in pitch than the first. The musical intervals most commonly used are the major or minor thirds, or a fourth, but some birds favour fifths.

(ii) Three notes, of which the first two are as in (i) and the third is of the same pitch as the first.

(iii) Three notes, of which the first two are of the same pitch and duration and the third higher in pitch, the intervals as in (i), and longer in duration (see plate 59d for a spectrogram of this call).

(iv) The exception mentioned above, in which three or more *pee* notes are prefixed by two or more of the non-musical *spick* sounds.

GROUP B. Calls in which *tsee* and the *pee* variants appear combined with notes of a strongly contrasted tone-quality and in which the associated behaviour seems always to have an aggressive or assertive element. This group is almost exclusive to adult males and is discussed in section I.

3. *Tsee*, the *pee* note variants and the calls described in group A above are almost always associated with movement, being used either immediately before or during flight. They are heard from birds on the move, either singly or in groups, and from paired birds keeping in contact with each other. Particularly during the autumn and early winter, these notes and calls will stimulate an individual to fly in the direction of others who are calling. My hand-reared tits would normally be roused into flying round the house and calling *pee* when hearing the *pee* notes of others passing through the garden. But it is important to note that the hand-reared birds also showed a strong internal rhythm as to times of "fly around" and *pee* calling. Quite regardless of whether other Great Tits were around outside or not, the house-living birds had certain times of day when the *pee* notes and calls accompanied much flying to and fro. Similarly, the colour-ringed birds I have had under close observation have also shown this internal rhythm which varies between individuals and in individuals over a period of several days. Thus, although there may be in general a considerable amount of calling about fifteen minutes after emerging from the roost on an autumn morning (usually a peak time), or in the half hour before roosting (another peak time), one notices that certain individuals may call very little on two or three successive days and then for a period of, say, six to ten days be very vocal.

4. Until the moult, I have heard no young bird give the true *tink* note (Hinde renders this as *twink*). This is the note described in *The Handbook* as a ringing Chaffinch-like *tink-tink-tink*. I find this a somewhat misleading description as, to my mind, what helps one to distinguish the two calls is the ringing or echo-like quality of the Great Tit call as opposed to the thicker sounding one of the Chaffinch (*Fringilla coelebs*), which is markedly lacking in echo. The Chaffinch *chink* is most liable to be taken as the Great Tit *tink* when the social version of the former (Marler 1956) is heard close to a house or in other acoustic conditions which favour echo.

Hinde speaks of gradations between *tsee* and *tink* notes and I

think this may account for the fact that I find myself in disagreement with him over the circumstances in which the *tink* notes are used. (See plate 59 in which a spectrogram of *tink* appears with those of *tsee*, a dulcet *pee* and the loudest form of *pee*, to illustrate the difference between all these notes.) Whereas Hinde found the *tink* call so commonly associated with flocking movements as to use it as an index of the frequency of calling during the day, and in different months, I have found that *tink*, as opposed to *tsee* and the various clearly distinguishable *pee* variants, is used almost exclusively by adult males.

Heinroth (1924-26) noted that a hand-reared female, kept for a full year, did not use either *tink* or what he described as the spring-call "*xiqibe*" and wrote: "It would be important to find out how far these notes are perhaps confined to male birds". I should add that I did not know of this observation until my own studies had already led me to conclude that *tink* was almost exclusively a male utterance and closely related to song.

Whereas *tsee*, the various *pee* notes and the calls derived from them have the effect of maintaining contact between Great Tits, the *tink* note has precisely the opposite effect. It is heard when Great Tits are moving through a garden or wood. But the birds it is heard from are those who are either returning to or already within their own territory or preferred area, or those who are trying to establish themselves within an area. In fact, *tink* is a call which indicates an assertive or aggressive attitude on the part of the bird making it; or so one would suppose from the various circumstances in which I have recorded it and noted the accompanying behaviour: (a) from males who are attempting to or who have established themselves in a preferred area or territory; (b) from males when they leave their roost holes in the morning and are in process of their "first thing in the morning" survey of their immediate surroundings; (c) from males when they re-enter their territories at different times during the day; (d) from males when they re-enter their territories at roosting time; (e) from males engaged in territorial disputes and boundary displays; (f) from males as a prelude to singing or when other males are singing.

It is easiest to show the place of *tink* in the behaviour cycle by a hypothetical but typical case history of a male at least two years old. The bird will hardly use *tink* at all during the moult. If, following the moult, he spends some time on his territory he is likely to start "tinking" particularly if there are wandering young males around. If he has a fairly considerable recrudescence of song during the early autumn months the amount of "tinking" will be less than if he sings little. When he comes again into full song (which may be any time from mid-November to mid-January) there will be less "tinking". If he has to undertake a considerable amount of territorial fighting (most likely

from the end of January to mid-March), he will have long "tinking" duels with his opponents; these duels will take place near to or on disputed boundaries and, where ground is ceded, the victor will sing. Once nesting activities are under way the bird will "tink" very much less, though during the course of nest building and incubation there may be outbursts of "tinking" during the first and last half hours of the day which he spends very close to the nest hole. Generally speaking, the more he sings at these times, the less he "tinks". Once he is engaged on the arduous business of getting food for the nestlings there is little or no "tinking" and very little song. This period, which is more or less simultaneous for a whole population, is one when territorial boundaries are generally ignored. "Tinking" and song are heard very little during the three weeks or so after the brood fledges (unless a second brood is undertaken) or from that time until the moult.

In the case of a first-year male—that is one who has just completed his first moult—*tink* enters his vocabulary while he is trying to establish himself within an area. I had a very clear picture of this from my hand-reared male. After the moult, this bird, which I aimed to free completely in the following spring and hoped would remain based on the house, was introduced by stages to each of its rooms. He started by "tinking" in the outside aviary, my library and the kitchen, the three places which had made up his world since he was a fledgling. At the same time as the "tinking" started, he also started aggressive displays at the males outside. It took him three or four days to master the required route—through the hall—from my library to the kitchen. Hitherto he had made the journey perched on my finger. As soon as this route was mastered he would "tink" from various vantage points in the hall, such as the coat rack or letter box. The ownership of each of the other rooms to which he found his way was similarly marked by outbursts of "tinking" and aggressive displays at males outside. When he first came into song—in November—he sang from various vantage points in all the rooms. When he became completely free flying, his first excursions into our garden, and neighbouring ones, were all marked by "tinking". He was, of course, trespassing into strongly held territories and was, at first, often forced to retreat into the house or his aviary. Here he would sing. Gradually, a *modus vivendi* was established by which the two outside males concerned ceded him the area immediately surrounding the house. Within this area he would sing.

Another example serves to show the relationship between "tinking", song and the internal state of the bird. Having discovered that a male, holding the territory which included the woodland in front of our house, took notice of recordings played by the open window, I

tried him out with several of his own and neighbouring songs and calls in order to observe his reactions. He would respond to recorded "tinks" (his own and other males') with song *if*, and *for as long as*, his threshold of song was low. Conversely, if one persisted long enough when playing him songs, he would eventually respond to song by "tinks".

From many observations of this kind, I suggest that "tinking" occurs when the bird is inhibited from song, and that this inhibition can result not only from external circumstances but from the internal state of the bird.

5. Although *tink* is not a normal constituent of the female vocabulary, it is occasionally heard from females. The circumstances in which I have heard it are:

(a) during unusually fierce reproductive fighting;

(b) when the female has been close to the chosen nest site shortly before or during the time of breeding; this is the one place in the territory with whose defence she is as actively concerned as the male and which, indeed, her mate may only enter at this time "by her permission";

(c) on one occasion only, from a female whose mate was in poor condition for three weeks or so in February and who was continually engaged in defending the territory against intruders; this female also sang during the same period, but neither "tinking" nor song were used any longer when her mate returned to normal condition three weeks or so later.

Generally speaking, it is the male who plays by far the greater part in defending, extending and proclaiming the territorial boundaries and it would seem biologically economical for the female not to waste energy on "tinking" and song if the territory is adequately defended by the male. In fact, the dissimilarity between the whole pattern of behaviour of the male and female during the late autumn and winter months is very noticeable and one facet of the difference is evidenced by comparing the vocabulary of the two. From at least early November onwards one is struck by the apparent abundance of energy shown by the male; he is forever rampaging about the place and it is at this season that one hears so many of the aggressive type of calls already mentioned and discussed in more detail below. The female confines her calling to *tsee*, *pee* notes and the other contact phrases derived from them. It is sometimes quite easy to overlook the presence of a female for several minutes until one has learnt by experience that she is most probably either engaged in a steady search for food or merely just sitting around; she appears to be much more occupied than is the male with "stoking up" and conserving her energies.

6. It is important to emphasise that the behaviour cycle of Great

Tits probably varies considerably in differing habitats. For instance, in the area where my most intensive observations have been made there has been little flocking by resident birds in the autumn and winter months. Those that are at least in their second year have all evinced territorial behaviour from shortly after the moult and have also spent much time in company with their mates. On the other hand, Hinde, the greater part of whose observations were made in an area of mixed woodland (one without houses and gardens), found a considerable amount of winter flocking, though the size of flocks varied in different years according to the presence or absence of locally abundant food supplies. During the period of winter flocking, Hinde found that it was difficult to tell if birds were paired or not and territorial behaviour only started when the winter flocks separated out. Comparing Hinde's findings on these points with my own, it seems obvious that, as between a population in which flocking occurs and one in which it does not, there is a noticeable difference in behaviour. And, of course, the difference in behaviour will be reflected in the calls which are heard. During those instances of flocking which I have had the opportunity to observe, I have only heard *tsee*, the *pee* notes and calls, churring and the various non-musical sounds associated with food-getting and fighting over food.

I. *Calls combining tsee, pee, tink and other notes*

There are three groups of calls, easily distinguished by ear, all of which fall, as far as the associated behaviour is concerned, into the second of the categories into which the *tsee* and *pee* note calls can be divided. All three groups are virtually exclusive to adult males.

1. Most of this group combine the *tsee* or *pee* and *tink* elements. One may hear *pee-tink-tink*, *pee-tink-pee-tink*, *tink-pee-tink* or other such combinations. Typically, these calls are used by males in situations very similar to those in which song or straightforward *tink* is heard. They enter—or re-enter—the vocabulary at the same time as *tink*. Many males use their own particular variants, of which they may have a number, after a prolonged burst of singing close to roosting time. Or a male may use them, between bursts of song, when waiting outside the nest site before the female emerges. In fact, they appear to indicate (as does *tink*) that the bird is, for some reason, inhibited from song. As with *tink*, “pee-tinking” is occasionally heard from females. In this group, also, are some other calls, used in exactly similar situations preceding or succeeding the *pee-tink* variants or song, in which the *pee* element is combined with one or more notes of a different tone-quality from either *pee* or *tink*.

2. Spectrograms of two examples of this group are shown in plate 61 (a and b). Both show the *pee* element combined with other musical

notes of a different tone quality and with sounds having strong noise components. It is these noise components which give the calls a very characteristic explosive effect. Onomatopoeic renderings* are: for (a) *chack-chack-ee*, *chack-chack-ee*; and for (b) *spick-spick-pee-pen-pen*. These calls are sometimes zipped off in groups of as many as fifteen or so. They are always associated with situations encountered in the establishment or defence of territory. Unlike those in the group discussed above, they are not used in circumstances where one can regard them as a sub-dominant form of song. Thus, they are rarely heard after the time when the territories in any given locality have been firmly established. When one does hear them after, say, mid-March, it usually indicates that wandering males are attempting to invade an occupied territory. They are most frequently heard when males are seeking to establish themselves during the autumn and also during the fierce territorial skirmishes in the early spring. As in the case of the *pee-tink* calls discussed above, an individual male may have three or four variants in his vocabulary.

3. Aurally, the calls in this group are composed of very vibrant *pee*-like notes which are always widely separated in pitch. Spectrograms of two examples are shown in plate 61 (c and d). These happen to be from the vocabulary of two different individuals, but each had both in his repertoire. Onomatopoeic renderings are: for (c) *i-yah-i-yah*; and for (d) *pee-hi-pee-hi*. Typically, these vibrant calls are used during reproductive fighting and also when the male has lost contact with the female. But the latter circumstance does not seem to stimulate a male to use them if reproductive skirmishing is at an end. I suspect, therefore, that this group of calls is particularly associated with territorial rivalry where possession of the female is under threat. When I have been sure of the circumstances, the intruding male has been unmated. If I am correct, then it explains the fact that these calls are used, along with other calls exclusively associated with absence of the female, when a male subject to pressure from unmated males has lost contact with his mate. In human terms, the mood of the male could be described as partly one of "angry suspicion".

J. "Muttered threat" phrase

In the vocabulary of adult males, there is one "muttered" phrase which, because of the nature of the utterance and its association with one particular aspect of behaviour, forces one to give it a category to itself. This is a phrase of three notes, which begins and ends on the same pitch, with the middle note lower. As with song and the *pee*

*These follow the recommendations for phonetic renderings given in *The Handbook*, except that italics are used throughout in accordance with the policy of this journal.

group calls, the interval may vary between individuals, but the pattern of the phrase is always the same, with the lower note heavily stressed. It is a very sibilant utterance, the sound being similar to a human's whistling between the teeth. Though it is only audible from a few feet, those whose bird tables are near to the window may have heard it from Great Tit males giving threat displays, either at members of their own or other *Parus* species. If one is close enough, or listening over a microphone, it is also to be heard during reproductive fighting, between rounds. One sometimes hears an apparently solitary male uttering these phrases; but, in the many instances where I have known the circumstances, this has always preceded or followed an aggressive encounter, or been delivered by an individual arriving at a place where he is used to encountering a territorial rival. In such instances one is irresistibly reminded of the muttered imprecations of humans in the condition known as "spoiling for a fight".

K. Song: introductory remarks

The basic phrases of the more stereotyped songs of the Great Tit are rendered by *The Handbook* as "teechū-teechū-teechū" and "teechūwee-teechūwee . . .". *The Handbook* and Hinde also state that a number of variants, some of them more elaborate, may be used by the same individual. The elements of variation are described and discussed below.

Normally, song is confined to the vocabulary of males who have completed their first moult. Hinde states that song may be heard from juvenile birds in late summer; but I have not heard it from any

PLATE 59 (*opposite*). Four sound-spectrograms of recordings made from the same individual male Great Tit (*Parus major*), by the same mechanical means and in approximately similar acoustic conditions.

- (a) shows three *tsee* notes followed by two dulcet *pee* notes. The *tsee* notes start at a frequency almost a full octave above the *pee* notes and glide downwards over a wide range of frequencies. The *pee* notes still show a downward curve, but over a much narrower range of frequencies. Thus, aurally, they are more easily assigned to a definite pitch.
- (b) shows loud *pee* notes—an aurally distinguishable gradation between the *pee* notes in (a) and the notes shown in (c).
- (c) *tink* notes. It will be seen that *tsee*, the dulcet *pee* and the loud *pee* all show a downward slope of differing gradients in contrast with the more or less level base line of *tink*.
- (d) shows one of the four common social calls described on page 382. Here, two of the loud *pee* notes shown in (b) are combined with yet another *pee* note variant which is higher in pitch and longer in duration.

The original spectrograms have a frequency scale from 0 to 10 kilocycles per second. However, all the Great Tit calls and songs shown here are of frequencies above 2 kilocycles per second, so for convenience of reproduction the lower part of the spectrogram has been omitted in each case and the scale, which, as will be seen, is logarithmic, starts at 1 kilocycle per second.

of the many juveniles I have had under close observation. All male Great Tits that I have heard—except those in their first season of singing—have had a repertoire of at least four clearly distinguishable songs.

As with many other species, the song of the Great Tit is associated with two particular situations: (a) those involving the ownership of, or disputes concerning, territory; and (b) the absence of the female. The relationship between the *ink* call and song has already been discussed and I have suggested that the internal state of the bird has some effect, regardless of external circumstances, on the times when it sings and the amount of song. The singing of territorial neighbours undoubtedly acts as a strong stimulus though, as I have already pointed out, a male whose threshold of song is high (i.e. one who may already have sung his full quota for the time being or whom other internal factors may be influencing) will respond to others' song by "tinks" from within his own territory. (I have a strong impression, which I have not yet verified by sufficient observation, that individuals have an internal rhythm resulting in a flood and ebb tide of song. Thus, for a number of days an individual will sing a great deal, regardless of external circumstances such as weather conditions or the amount of song from immediate territorial neighbours; then follows a shorter period during which the same bird does much less singing except when external circumstances, so to speak, drive him to do so—and during this period he will often respond to others' song by "tinking".)

L. Behaviour during song

While singing, as in all its activities, a Great Tit is an engaging creature to watch. For a lengthy spell, it often sings from the highest perch available on one of a number of chosen trees; turning, from time to time, to face north, south, east and west. During less intense song spells it sings at lower levels and will constantly interrupt itself to tear at buds, hammer at bark, or preen, scratch or peck at its toes. If it is engaging in a song duel it will often fly from one song post to another, and then another, each taking it nearer the rival against whom it is singing. As the rival may do the same, they then end up facing each other on their respective border song posts. Or the converse may take place, each bird starting at the boundary and retreating inwards towards the heart of its territory.

During reproductive fighting, snatches of the various songs in the individuals' repertoires are interspersed with the various aggressive-type calls already discussed, "pit-churring" and a splutter of "spicks", "pits", "chits" and other non-musical sounds. (A really fierce skirmish provides the most striking demonstration of the Great Tit's vocal virtuosity and is one of the many occasions causing one to bless

the invention of the tape-recorder—if it has been switched on.)

Once nesting has begun, a great deal of song is delivered close to the nest site, particularly while the male is waiting for the female to emerge from the nest hole at dawn. But if the male is roosting at some distance from the nest hole, he is likely to start the morning by “beating the bounds” with song *en route* for the nest site, and he will end the day in the same way.

M. *Season of full song*

The chart of song periods in *The Handbook* shows the Great Tit as irregular but frequent between mid-August and mid-October, as exceptional from mid-October to mid-December, as irregular but frequent for the last two weeks of December and then as constant until mid-June. My observations show that in any one year individuals vary in the times of onset of full song; for instance, in 1960-61 there was a difference of three and a half weeks between the two males whose territories included part of our garden—though both were spending the major part of the day on their territories and both were keeping close contact with their mates. Apart from these individual variations, it is my impression that, as a general rule, those birds whose territories are close to houses tend to come into song earlier than those in pure woodland, some of the former being in full song by the end of November.

I consider an individual to be in full song when his complete repertoire has re-entered his vocabulary. This is usually an index of the amount he is singing. At the period when he is beginning to sing again, he normally starts with only one or two of his songs. As song becomes more frequent the other variants are added.

N. *Female song*

Hinde states that “singing by female Great Tits is not common, but was heard fairly often when the females were taking part in reproductive fighting, and also just before nest building, in situations which could be interpreted as ‘absence of the male’.” I agree with him that female song is not common, but my observations have given only one instance of true song during reproductive fighting and none at the time of nest building. What one does sometimes hear from females at these times is, as I have already stated, either “tinking” or “pee-tinking”. I think this distinction is important since, although “pee-tinking” is aurally very similar and closely related to song, both it and “tinking” indicate that the individual is inhibited from true song.

I also disagree with Hinde in attributing the stimulus for female singing to “absence of the male”. The instance I have quoted above (given in detail in section H5), in which a female was temporarily

forced to undertake the defence of a territory, suggests strongly that song by female Great Tits is produced in situations like that described by Nice (1943). Discussing the function of song in female birds, she wrote: "Where song is largely specialised for territorial uses, and territorial defence is primarily taken over by one sex, then song is most highly developed in this sex, and may almost disappear in the other. *In individual cases where territorial responsibilities are thrust upon the normally less active bird, it may respond with excellent song*" (my italics).

Although the male Great Tit is undoubtedly stimulated to sing in the absence of the female, there seems no doubt that, in this species, song is "largely specialised for territorial uses" and there is thus good reason for it to be highly exceptional in females.

O. *Song: musical analysis*

(This section has been written jointly by the author and R. E. Jellis)

1. Compared with the songs of such singers as the Robin (*Erithacus rubecula*) or Blackbird (*Turdus merula*), the Great Tit's is a simple utterance. It consists of units of two notes (the most common form), or three or four. We have neither transcribed nor recorded any singer with a unit of more than four notes. The bird normally repeats each unit several times, and then, after a pause, delivers several more units in succession. For example, the bird may utter its song thus: 7 units, pause, 8, pause, 8, pause, 7, pause, 5, pause, 5, pause, 5, pause, 6. During intense spells—particularly in song duels—there may be a single utterance of as long as twenty seconds. One or two such lengthy utterances are almost invariably followed by a very short one.

It is rare for a Great Tit two or more years old to have less than four clearly distinguishable songs in its repertoire; five is quite common; the most we have noted or recorded is seven.

2. Given two or more notes to play with, a bird, like a human musician, can vary them in five basic ways: (a) actual pitch; (b) interval; (c) rhythm and stress; (d) tempo; and (e) tone-quality.

(a) Aurally, actual pitch can only be assigned approximately, to the nearest semitone of the tempered scale on the piano or the pitch-pipe. It is extremely useful, nevertheless, as a guide to the range, and the relationship, of the notes which are used by a bird in different songs.

(b) Intervals of a second or full tone, major and minor thirds, fourths and fifths have been recorded and transcribed in two-note songs, and varying combinations of them in the three- and four-note songs.

(c) We use "rhythm" to indicate the relative duration and grouping of the notes of a song, and "stress" to mean the note which is most strongly emphasised—the first beat of the bar, as it were. In a two-

note song, there are a limited number of variants which the bird can make with rhythm and stress alone and at one time or another we have recorded or transcribed all of them. In the case of three- or four-note songs, the possible variations are enormously increased.

(d) There is a wide variation in the speeds used by an individual bird in his different songs. To make a formal basis for comparison in the field, and when analysing recordings aurally, we have adopted the musical method of metronome marking. A metronome mark of 120 means that the bird would deliver 120 song units in one minute of unbroken utterance, or two in every second. Since, of course, the bird does not, obligingly, utter song units for a full minute without a break, one obtains the metronome mark by a count of the longest possible stretch of units over a convenient period of seconds and by multiplying accordingly. This is a reasonably accurate measure of the variations in speed between either the songs of an individual bird, or of two different singers. The results obtained by this method check well with measurements made on spectrograms. All the individuals we have heard had among their songs three of considerably different tempi: one slow, Mm 70-120; one medium Mm 120-160; one fast, Mm 160-200.

(e) Apart from variation in voice quality between one bird and another, there is also variation between one note and another produced by the same bird. For example, in a two-note song, both notes may be fairly "pure", or flute-like, to our ears, or one or both notes may sound "reedy" rather than flute-like, or seem to have more "noise" in them; or their exact pitch may be less obvious (at half speed or on the spectrogram the latter may be revealed as a steep glide covering a semitone or more).

3. Plate 60 (a-f and h) shows spectrograms of the seven songs forming the present repertoire of one individual. It will be seen that the singer makes use of all the elements of variation discussed above. The first song (a) is extremely distinctive, being, in fact, the common chord of F# Major sung as a descending arpeggio in a dotted rhythm, with the stress placed on the tonic at the top and on the mediant. The next four songs (b-e) each make use of a different interval.

Variations of rhythm and stress are shown by the way the notes within each unit are spaced in time, and by their relative duration; and tempo is measured by the distance between the beginning of the first note of one unit and the first note of the next—the shorter the distance the quicker the tempo. In these five, there is one slow song (a), two medium (c and e) and two fast (b and d). The two medium songs differ in pitch, interval and stress, however, as do the two fast ones.

The fourth song (d) also differs strikingly from any other in this repertoire. It is totally dissimilar in tone-quality (see below). The

spectrogram reveals that the first note of each unit consists of two sounds, approximately an octave apart in pitch. They are simultaneously delivered, but their time patterns are such that it seems possible that they are independently generated by the bird. We have found that listeners differ in their selection of the musical interval they are hearing, so that one will state that the song unit is an ascending major third and another that it is a descending minor sixth.

The fifth song (e) is an example of one which, heard at normal speed, sounds to the human ear as if it were composed of two notes with the top note a steep glide, whereas, in fact, as listening at half speed and the spectrogram both show, it is a three-note song.

The other two songs in the repertoire (f and h) are both medium-slow in tempo, but differ in pitch, interval, rhythm and stress.

It may be that the fifth element of variation discussed above—tone quality—is revealed in the spectrograms by the considerable difference in the frequency spread of the notes, by their duration and by the alteration of the pattern of frequencies within a single note. But to relate in detail the highly subjective aural appreciation of tone-quality to its physical basis goes far beyond the scope of the present study. However, we must stress the fact that all the songs illustrated have considerable variations of tone-quality.

Musicians will, no doubt, be interested to observe that this individual operated within a strongly tonal framework—within the key of F \sharp Major. But this was not the case with the other five birds whose full repertoire was recorded.

P. Song: significance of variation

Hinde remarks that the significance of song variation in the Great Tit is obscure: “. . . one individual may use several different song types in succession when there has been no apparent change in the external situation . . .”

It does not seem to me that one has far to look for the first circumstance which will motivate an individual to ring the changes in song. This has been described by Hartshorne (1958) as the “anti-monotony” principle; “. . . it appears . . . that even birds,” he writes, “can stand a prolonged succession of songs or phrases separated by brief intervals of silence (less than two or three seconds) only if there is a considerable variety among the songs or phrases. . . . Birds in this respect act musically as we do, save that their temporal span, beyond which monotony is not felt, is brief and that very simple variations satisfy them.” Since a Great Tit may spend a considerable proportion of its day in singing (which may include periods of as long as fifteen minutes without a break of more than one minute), it seems reasonable to assume that the “anti-monotony” principle is one good reason for it

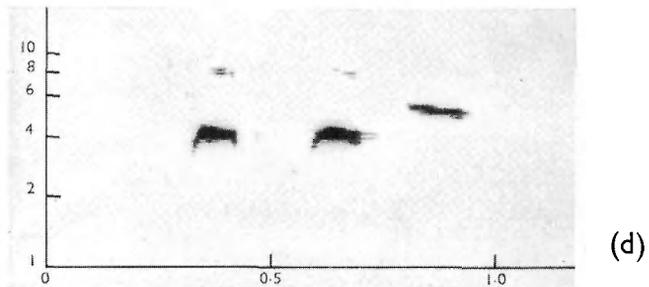
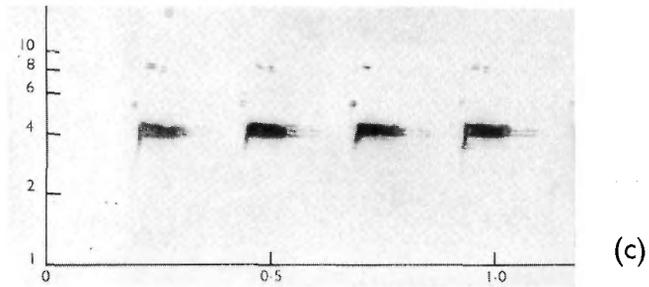
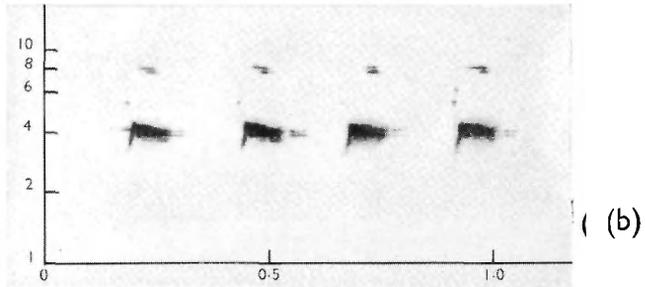
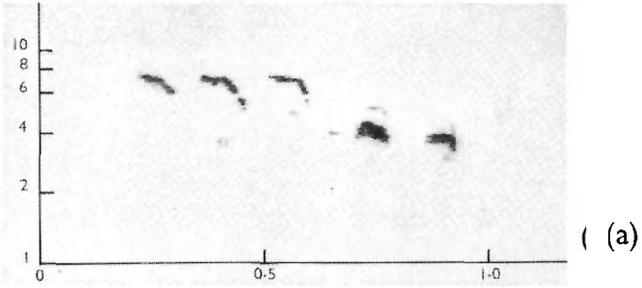
to vary its songs. That this is so is, I think, evidenced by the fact that, in a prolonged burst of singing, a Great Tit always does change from one to another of its songs and, in doing so, normally switches to a song of a different tempo. The longest I have ever heard an individual continue to sing the same song was eight minutes, by the end of which time I certainly felt that it was high time for a change. Three to five minutes is a much more usual period for one song to last before another succeeds it.

The second cause of variations in the songs of individual birds and similarity in a local repertoire is the tendency for territorial neighbours to produce approximations to their rivals' songs. During song-duels, each male tends to use that song in his repertoire most closely similar in tempo and rhythm to that which his rival is singing (plate 60, f and g, h and i, shows two instances of this). And if, when a Great Tit is singing, one plays him the recording of a different song in his own repertoire, he tends to switch to that song within a few seconds. In spite of this tendency to use similar song types during song-duels, Great Tits also maintain variants in their song repertoire which do not approximate to those of their territorial rivals. For instance, in the case of the bird whose full repertoire is illustrated in plate 60, though no other within a half-mile radius sang anything remotely like his first song (a), this has remained in daily use throughout two seasons. In this respect the Great Tit would appear to differ from the Chaffinch (*Fringilla coelebs*), for Marler (1956b) found that males of that species tended to drop songs which did not approximate to those of their territorial neighbours.

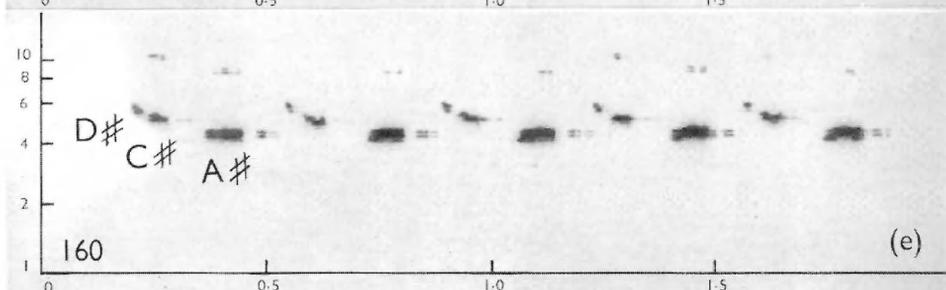
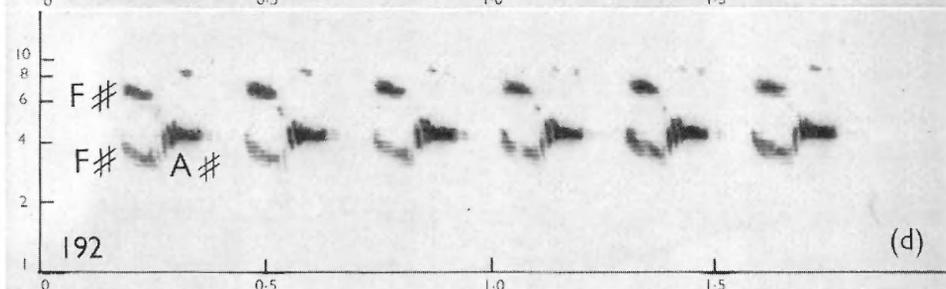
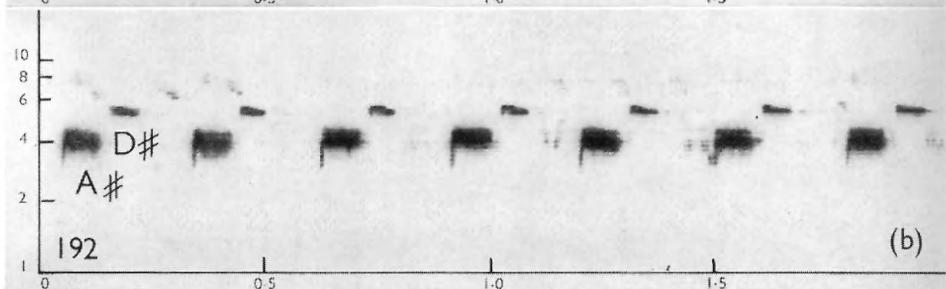
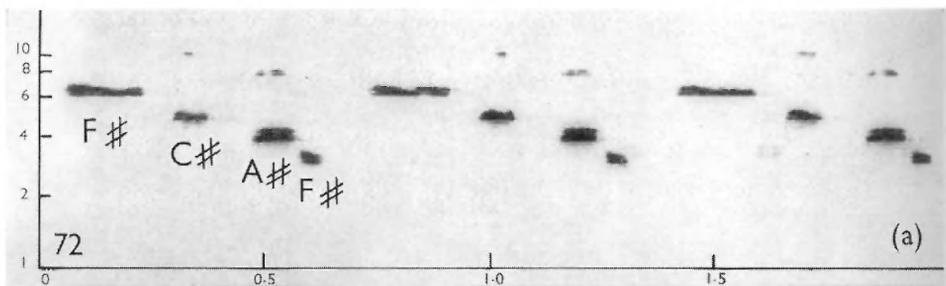
There is one other interesting possibility in the variation of songs which should be mentioned. Do any or all of the songs have any special relation to any special external circumstance? For example, does one song, rather than any of the others, tend to be sung in the absence of the female? In the cases of two birds where I have been in a position to ask this question with some reasonable chance of acquiring a useful lead or two, I have had entirely negative results. It seems to me that, apart from the already mentioned tendency to use the nearest approximation in tempo and rhythm to his rival's during a duel, a Great Tit may sing each or any song in his repertoire in any circumstance.

(To be concluded)

The vertical scale is the frequency in kilocycles per second, the horizontal the time in seconds



The vertical scale is the frequency in kilocycles per second, the horizontal the time in seconds



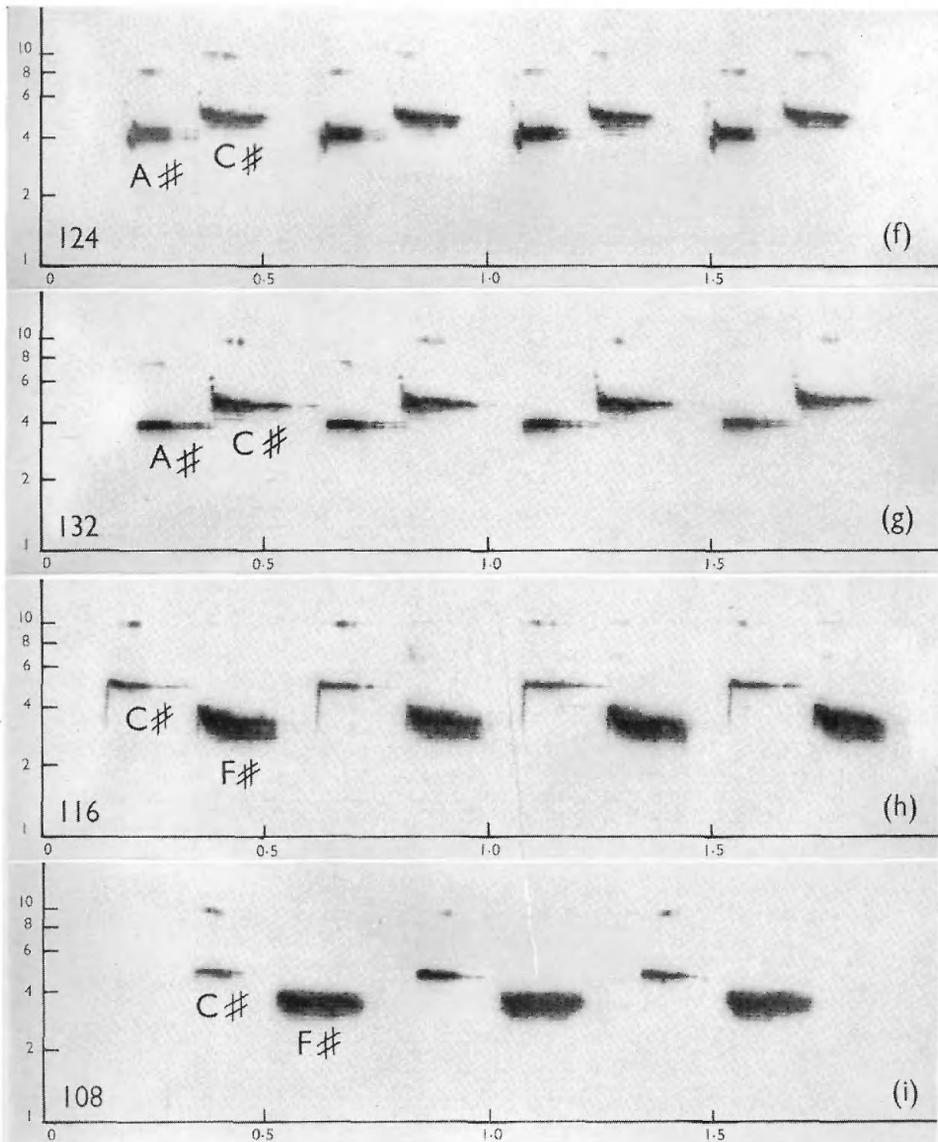


PLATE 60. Songs of two Great Tits (*Parus major*). (a) to (e) are five of the seven songs forming the repertoire of one male, Bluewhite. His other two songs are shown in (f) and (h) for comparison with two similar songs, (g) and (i), of a rival male; (f) and (h) are the two songs in Bluewhite's repertoire which most closely approximate to (g) and (i)—see page 394—and, in song duels between these two, (f) is used against (g) and (h) against (i). The pitch assigned by the human ear (the mean of the frequency range on the spectrogram) is given under the notes comprising the first unit of each song. The figure in each bottom left-hand corner represents the number of units delivered in one minute and shows the tempo. The elements of musical variation of these songs are discussed on pages 391-393

The vertical scale is the frequency in kilocycles per second, the horizontal the time in seconds

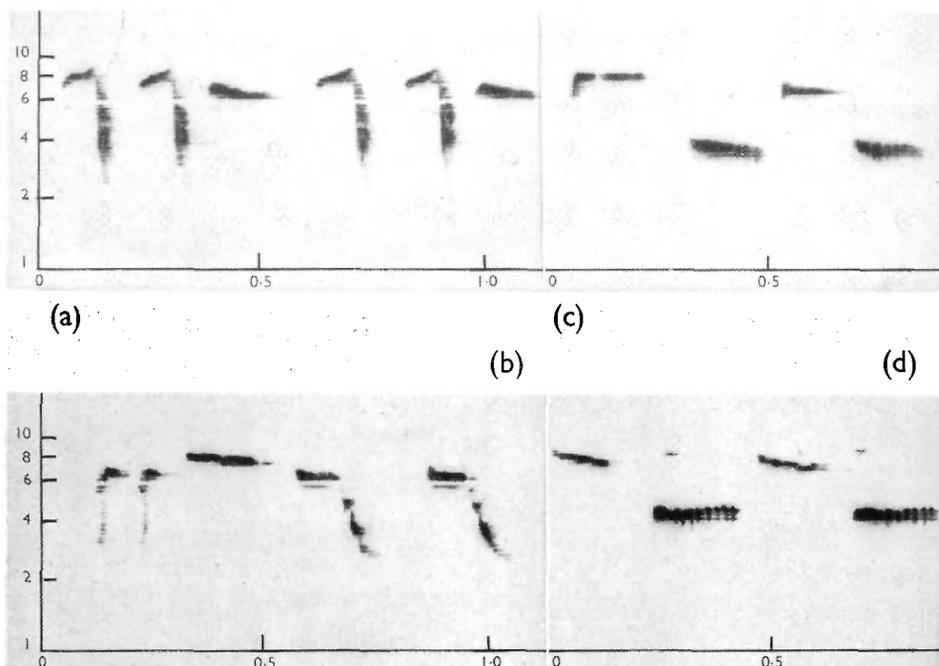
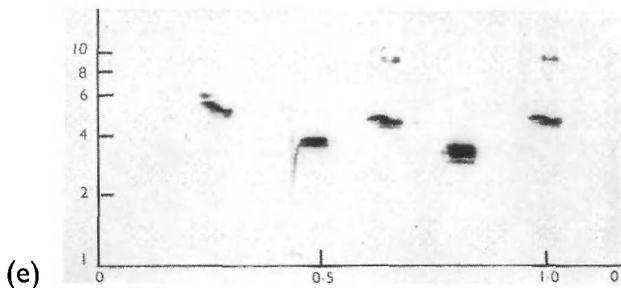


PLATE 61. Calls of Great Tit (*Parus major*). (a) and (b)—above left—are examples combining *pee* note variants with other musical and non-musical sounds; the latter are seen as long vertical patterns over a wide range of frequencies (page 386). (c) and (d)—above right—are vibrant calls in which the *pee* note variants composing them are widely separated in frequency and long in duration (page 387)



An example of a "duple" call, recorded from a male (page 411 in next issue). Of the five notes used, the first is one of this bird's *pee* note variants, the third and fifth another, and the fourth a different one again; the second is his *tink* note (this is not the male whose *pee* note variants and *tink* are shown on plate 59)