

**THE QUANTITATIVE GENETICS OF SOUND PRODUCTION IN *GRYLLUS*
*FIRNUS***

Karen Lynn Webb
Department of Biology,
McGill University, Montreal
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(C) Karen Lynn Webb
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PREFACE

This thesis conforms to the requirements explained in 'Guidelines Concerning Thesis Preparation'. The thesis will, in part, be modified for future submission for possible publication. However, at the time of thesis submission, no submission for publication has been made.

There is no published record, to my knowledge, or to the knowledge of my thesis supervisor, of the quantitative genetics of components of a cricket calling song, and the morphology of the sound producing structures. After the thesis work had begun, however, a similar study was published on the song and morphology of the grasshopper, *Chorthippus brunneus*, although, sample sizes were comparably small (Butlin and Hewitt 1986).

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ABSTRACT

The species-specific calling songs of male crickets are used by females for species recognition and mate choice. Heritabilities of variation of morphological structures involved in song production, components of the calling song, and body size were estimated for *G.firmus*. All morphological structures were shown to possess significant additive genetic variation ($h^2_{S+D} > 0.42$). One of the five song components examined, pulse rate, was shown to have a significant heritability ($h^2_{S+D} = 0.35$). Due to the low correlation between body size and song components, it is unlikely that female *G.firmus* could use the calling song to assess male body size or wing morph (micropterous or macropterous).

Résumé

Les grillons femelles sont attirés par le cri des grillons mâles, caractéristiques à chaque espèce, pour l'identification de l'espèce et pour le choix du partenaire reproducteur. La capacité génétique de transfert à la descendance (heritability) de la variation des structures morphologiques impliquées dans l'émission du cri, les composantes du cri et les mensurations corporelles ont été mesurés chez *G.firmus*. Toutes les structures morphologiques possèdent une variation génétique additive qui est significative ($h^2_{S+D} > 0.42$). L'une des cinq composantes du cri examinées, le pouls, possède une capacité génétique de transfert à la descendance qui est significative ($h^2_{S+D} = 0.35$). La faible corrélation qui existe entre les mensurations corporelles et les composantes du cri suggère qu'il est peu probable que les femelles *G.firmus* utilisent le cri pour déterminer les mensurations corporelles ou la morphologie ailaire (microptère ou macroptère) des mâles.

Translated by Pierre Aquin

INTRODUCTION

Song, as a male display, is an important component of mating systems in many anurans, birds, and insects (Brooks and Falls 1975; Wells 1977; Davies and Halliday 1978; Falls 1982; Arak 1983; Stout et al 1983). Song may be used to convey information not only about the location of the caller but also about its physical characteristics, such as size; for example, the pitch (frequency) of advertisement calls of the toads, *Bufo bufo* and *Bufo calamita*, are used to assess male body size and fighting ability when competing for calling sites (Davies and Halliday 1978; Arak 1983). Similarly, Simmons (1988b) found a significant increase in the pulse repetition rate and a decrease in chirp duration with increasing male size for the cricket, *Gryllus bimaculatus*. That these song components can be assessed by the female cricket is evidenced by the observation that females preferred the calls of large males in playback experiments (Simmons 1988b).

In Orthoptera the songs are a major component of the mate recognition system (Regen 1913; Walker 1957; Popov et al 1974; Popov and Shuvalov 1977; Pollack and Hoy 1981; Weber et al 1981; Pollack 1982; Thorson et al 1982; Stout et al 1983; Doherty 1985a, b). The temporal parameters of cricket calling songs used by females for species recognition and phonotaxis have been extensively studied (Walker 1957; Popov et al 1974; Popov and Shuvalov 1977; Pollack and Hoy 1981; Weber et al 1981; Pollack 1982; Thorson et al 1982; Stout et al 1983; Doherty 1985a, b). Furthermore, it has been demonstrated that cricket song characteristics are under strict polygenic control with males producing the species specific song without previous exposure to it (Bentley 1971). Components of the calling song found to be important in many species of crickets for

species recognition and female phonotaxis are number of pulses per chirp, pulse length, pulse repetition rate within chirps (1/pulse period), chirp length, and carrier frequency (most intense frequency component) (Doherty and Hoy 1985). Females appear to evaluate several of these components (for a review see Doherty and Hoy 1985); if females differ in their evaluation of song attractiveness, and the song components assessed are heritable, variations in song may persist. Furthermore, additive genetic variance in male traits that are important components of fitness may not be eroded as simple theories of sexual selection predict (Maynard Smith 1978). For example, Hedrick (1988) found that calling bout length, in the cricket *Gryllus integer*, was significantly heritable (Father-son regression, Arcsine-transformed $h^2=0.75$, $P<0.0005$), and virgin females were preferentially attracted to long calling bout lengths (Hedrick 1986). However, little is known, overall, about genetic variation in the components of the calling song within Orthopteran species, and their effects on female mate choice (see Crankshaw 1979; Hedrick 1986, 1988; Simmons 1987, 1988b). Butlin and Hewitt (1986) examined the heritability of morphology and song characteristics of the grasshopper, *Chorthippus brunneus*. Heritabilities for morphological features were generally higher than song components ($h^2 = -0.21$ to 0.28 for song components, and $h^2 = 0.16$ to 0.89 for morphological features). None of the heritability estimates for song components were significant; however, this may be due to the small sample size ($90 < n < 95$) with the consequently high standard errors (Butlin and Hewitt 1986).

The sand cricket, *Gryllus firmus*, is a large ground dwelling cricket native to the southeastern United States (Alexander 1968), and is well suited as a subject for the analysis of heritability of both morphological and song components. It is easy to rear in large numbers and the

generation time is relatively short (approximately 60 days from egg to adult at 28°C). Males of *G.firmus* produce three types of calls; a calling song that attracts females from a distance, a courtship song that is used by the male when in very close proximity to the female, and an aggressive song used primarily in male-male interactions. The courtship song may be an important secondary mechanism by which species recognition may occur, and is required by females of some species to mate (Burk 1982; Crankshaw 1979). However, the courtship song is more complex than the calling song, and difficult to quantify (personal observation; also see Alexander 1961). Therefore, in this study, the courtship song was not examined, our analysis being restricted to the primary mechanism of species discrimination, the calling song.

The calling song of *G.firmus* is simple in structure consisting of distinct chirps of 3-5 pulses per chirp (Figure 1). The calling song is produced by lifting the tegmina at a 30-45° angle from the abdomen, and rubbing the scraper of the lowermost tegmen over the stridulatory file on the lower surface of the uppermost tegmen (usually the right tegmen) upon wing closure (Rakshpal 1960). In this paper we report on an experiment to determine the heritabilities and phenotypic correlations between the following components of the calling song: number of pulses per chirp; pulse length; pulse rate; chirp length; and carrier frequency. Here "heritability" refers to *heritability in the narrow sense*, defined as the ratio of additive genetic variance for the given trait to its total phenotypic variance (Falconer 1981).

In addition to the song components we estimated the heritability of the sound producing structures: the number of teeth on the stridulatory file; the length of the stridulatory file covered by stridulatory teeth; and the

resonator area. Although the harp is the radiator of the calling song carrier frequency of *Gryllus* males (Michelsen and Nocke 1974), it was not measured as no definite upper boundary exists (Figure 2). The resonator contributes to the overall power output of the sound produced, contributing to the efficiency of the tegmen as a sound producing organ (Lutz and Hicks 1930; Michelsen and Nocke 1974). In addition to heritability estimates, we measured the phenotypic correlations between song and sound producing structures to determine the effects of variation in these structures on the sound produced.

The study by Simmons (1988b) suggests that female *Gryllus bimaculatus* may prefer large males, and discriminate size based on characteristics of the calling song. We examined the likelihood that female *G.firmus* can use components of the calling song to assess size by computing the phenotypic correlation between body size, as measured by femur length, and the song components. Additionally, we estimated the phenotypic correlations between femur length and the other morphological structures examined (number of stridulatory teeth, file length, and resonator area) and the heritability of femur length.

G.firmus is dimorphic with respect to flight wing length. Macropterous individuals possess the ability to fly, and therefore the choice of dispersal, while micropterous individuals are unable to fly. The wing dimorphism has a polygenic basis, and micropterous parents produce a higher proportion of micropterous offspring than macropterous parents (Roff 1986). Although in females there is a reproductive "cost", in terms of a delay to reproduction and a reduced fecundity, associated with macroptery, the benefit of producing a few dispersing offspring is likely to offset that cost, leading to the maintenance of the two forms in the population (Roff 1984).

Differences in morphology, and variations in song between morphs was examined to determine whether the calling song of *G.firmus* males could be used to assess wing morph, and thereby enable females to preferentially select males of a particular wing morph by using only information within the calling song.

METHODS

The crickets used in the present study descended from an original group of approximately 40 individuals (about 20 females) collected 7 years before the start of this study from a single location in northern Florida.

Heritability estimates were obtained using a half-sib design (Falconer 1981). The parental generation consisted of offspring from a control stock maintained during the course of a selection experiment (see Roff 1990). Sixty nymphs per cage were raised at 30°C with a 15L:9D photoperiod in 29cm L x 19cm W x 13cm H polystyrene mouse cages covered with a glass sheet. Air circulation was provided by an approximately 1cm diameter hole on each side of the cages, covered with wire mesh to prevent nymphs from escaping. Nymphs were fed Purina^(C) Rabbit Chow *ad libitum*, and water was supplied through a shell vial with a cotton plug.

Once molt to the adult stage had commenced, cages were inspected daily and new adults removed. Male and female virgins obtained in this manner were chosen randomly as parents for the study. The analysis of Robertson (1959) suggests that for a half-sib design 4 dams per sire, and family sizes of 10 individuals are optimal. In the present experiment logistic considerations dictated 8 sires, giving a total of 32 families, and a maximum sample size of 320 offspring.

Mated dams were each provided with an oviposition box (plastic sandwich box filled with moist sterilized soil). When the eggs started to hatch, the boxes were removed and kept at 28°C. The egg boxes were checked daily, and all nymphs removed. To permit a nested analysis for the estimation of common environment effects, two nymph cages,

comprising 60 nymphs each, were set up from each dam's offspring. Nymphs were raised at 28°C with a 15L:9D photoperiod in white 4 liter plastic buckets (Vulcan(R) Industrial Packaging, Ltd). Air circulation was provided by two 1cm holes covered with wire mesh in the bucket lids. Nymphs were fed Purina(C) Rabbit Chow *ad libitum*, and water supplied through a shell vial with a cotton stopper. Ten adult males of known age were collected from each dam family (attempts were made to collect 5 from each cage, otherwise 4 and 6 were collected). The adult males were individually caged to minimize the risk of damage in aggressive interactions, and for individual identification. Males were housed individually in cages made by inserting a loop of wire mesh secured with masking tape, with an approximate height of 3cm between the top and bottom of a 150mm x 15mm plastic disposable petri dish (Figure 3). Water was supplied by a cheesecloth wick extending through a hole in the floor of the cage to a reservoir of water contained in a second petri dish. Purina(C) Rabbit Chow was supplied *ad libitum*.

Cade and Wyatt(1984) found calling by the adult male, on average, occurs by age 7 days post eclosion at 19-26°C for *Gryllus integer*, *G. pennsylvanicus*, *G. veletis*, and *Teleogryllus africanus*. Therefore, to avoid attempting to record males that have not yet begun to sing, the first recording attempts were made at the minimum age of 7 days. In the laboratory, *G. firmus* males call at or near "dawn" (onset of the light phase of the light cycle) and continue to call throughout the day, with little or no calling during the night (personal observation). Consequently, the best recording results (higher number of individuals recorded) were obtained when recording commenced at or near "dawn". Recording sessions for each day were started within an hour of the onset of the light phase of the light cycle.

Recordings were made using a Uher 4200 Report with a Uher M538 microphone, speed set at 9.5cmPS. To minimize extraneous noise all recordings were made in an anechoic chamber. Temperature was maintained between 30°C and 33°C, as Doherty (1985b) found little change in song characteristics with change in temperatures above 24°C in the chirping species *Gryllus bimaculatus*. The heating of the anechoic chamber above 22°C was provided by an infrared 250 Philips heating lamp suspended approximately 50cm above the cricket cage, and intensity was adjusted with a light dimmer, as needed, to maintain the temperature range. Attempts were made to acquire a minimum of 100-200 chirps per individual. Calling was induced by placing an adult female in the, otherwise isolated, male's cage. If courtship resulted, the pair was disturbed to avoid the possibility of courting indefinitely, or mating (after which the male remains silent). The female was replaced if she appeared receptive to the male. Courting males, interrupted by the departure of the female, may start calling again (Alexander 1962). An unresponsive female, remaining in close proximity to the male, may elicit aggressive chirps (louder and typically containing more pulses than the calling song) from the male. This may then lead to the production of the calling song, or the cessation of stridulation altogether (Alexander 1961).

The calling songs were analyzed at Brock University, St. Catharines, Ontario, using the Brock University Digital Signal Processing Network (see Appendix 1). The songs of 170 individuals were successfully analyzed (except frequency where $n=163$), which was 1-10 individuals per dam family (mean=5.3, median=5.5, standard deviation, S.D.=2.0).

Males were killed, by immersion in ethyl alcohol, when no longer required for calling song recording. Males were then placed in individually labelled bags, and frozen

(-20°C) until needed for measurement of the morphological features. The hind left femur (the right if the left was missing) of each male was mounted between two slides. Femur length was measured by projecting onto a Houston Instrument Hipad™ Digitizer with an Omega Enlarger B22. The uppermost tegmen was removed, and a clear replica made of the lower surface. Replicas were made by sweeping a solution made by dissolving acetate sheet in acetone (stirring until it is smooth and has the consistency of nail varnish) onto the ventral surface of the tegmen. This solution dried within 1-2 minutes and was easily removed from the original tegmen without any apparent damage to the tegmen or significant shrinkage of the replica. This method proved better than the use of nail varnish (Ragge 1969), which takes longer to dry and often leads to the damage of the original tegmen, and the replica, when they are separated. The lateral surface of the tegmen was removed to facilitate the replication process. Rakshpal (1960) found that this area does not affect the modulating quality of the song, only intensity, which appears not to be an important factor in female choice (see Simmons 1988b). Both the original and the replica tegmen were mounted on a slide and held in place with a cover slip.

Teeth on the stridulatory files were counted using a Carl Zeiss light microscope on the F40/65 objective with Kpl w10x/18 oculars. The length of the stridulatory file was measured by projecting the image of the tegmen replica on a digitizer pad, using a Ken-A-Vision Microprojector, model x-1000-1. Only the part of the stridulatory vein covered by stridulatory teeth was measured (Figure 2), which could be easily seen on the enlarged image of a tegmen replica. The original tegmina are too opaque for this purpose. The resonator area was measured using the original tegmen on the same digitizer as the femur length. For the morphological features a total of 320 offspring were measured (except

resonator area where 319 were measured, due to half the tegmen missing from one individual), 10 male offspring from each of the dam families (for resonator area 9 individuals were measured in one of the dam families).

Statistical analyses required to calculate the heritability estimates were performed using Statgraphics version 2.6 for balanced data, and using SAS, general linear models procedures, for the unbalanced data. All other statistical analyses, regressions, etc. were performed with SYSTAT.

Formulas for the calculation of the heritabilities were taken from Becker (1985, pages 57-65):

$$h^2_S = 4\sigma^2_S / (\sigma^2_S + \sigma^2_D + \sigma^2_W)$$

$$h^2_D = 4\sigma^2_D / (\sigma^2_S + \sigma^2_D + \sigma^2_W)$$

$$h^2_{S+D} = 2(\sigma^2_S + \sigma^2_D) / (\sigma^2_S + \sigma^2_D + \sigma^2_W)$$

where the variance components are estimated as:

$$\sigma^2_W = MS_W$$

$$\sigma^2_D = (MS_D - MS_W) / k_1$$

$$\sigma^2_S = (MS_S - (MS_W + k_2\sigma^2_D)) / k_3$$

MS_W , MS_S , and MS_D are the Mean Squares estimated by Nested ANOVA (General Linear Models Procedure Estimate).

For a balanced design:

$$k_1 = k_2 = \text{number of progeny per dam}$$

$$k_3 = \text{number of progeny per sire}$$

for an unbalanced design (unequal number of progeny per family):

$$k_1 = (n_{..} - \sum_i (\sum_j n_{ij} / n_{i.})) / d.f. (D)$$

$$k_2 = ((\sum_i (\sum_j n_{ij}^2 / n_{i.})) - ((\sum_i \sum_j n_{ij}^2) / n_{..})) / d.f. (S)$$

$$k_3 = (n_{..} - \sum_i n_{i.}^2 / n_{..}) / d.f. (S)$$

where:

$n_{..}$ = total number of progeny

$n_{i.}$ = number of progeny per sire

n_{ij} = number of progeny per dam

S = number of sires

D = total number of dams

$d.f. (S) = S-1$

$d.f. (D) = D-S$

$d.f. (W) = n_{..} - D$

The Standard Errors, square root of the variances, for the heritability estimates were calculated as follows:

$$\sigma^2_T = \sigma^2_S + \sigma^2_D + \sigma^2_W$$

$$\text{var } \sigma^2_S = (2/k_3^2) * ((MS_S^2 / d.f. (S) + 2) + (MS_D^2 / d.f. (D) + 2))$$

$$\text{var}(h^2_S) = (4^2 * \text{var } \sigma^2_T) / (\sigma^2_T)^2$$

$$\text{var } \sigma^2_D = (2/k_1^2) * ((MS_D^2 / d.f. (D) + 2) + (MS_W^2 / d.f. (W) + 2))$$

$$\text{var}(h^2_D) = (4^2 * \text{var } \sigma^2_S) / (\sigma^2_T)^2$$

$$\text{cov}(\sigma^2_S \sigma^2_D) = (-2 MS_D^2 / d.f. (D) + 2) / k_1 k_3$$

$$\text{var}(h^2_{S+D}) = 2^2 (\text{var } \sigma^2_S + \text{var } \sigma^2_D + 2 \text{cov}(\sigma^2_S \sigma^2_D)) / (\sigma^2_T)^2$$

RESULTS

No significant cage effects were found. Therefore, the data from individual cages were pooled for each family.

The experimental animals consist of 176 micropterous (short winged), 136 macropterous (long winged, capable of flight) individuals, and 8 individuals of intermediate wing length.

1 Heritability

Both morphological features and song components exhibit moderate ranges in phenotypic variation, coefficients of variation ranging from 4% to 14% (Table I). Heritability estimates for all the morphological features are significant for the dam component (half-sib) and the full-sib(sire + dam) estimates (Table II). However, the heritability estimates of only one of the song components, the intrachirp pulse rate, is significant (full-sib estimate; Table II). The heritability estimates for the number of pulses per chirp, pulse length, chirp length and frequency are not significant.

To determine whether significant genetic variation was due to genetic differences between wing morphs (micropterous, intermediate, macropterous), heritability estimates were made after correcting for wing morph (adjusting means to zero), and are reported in Table III. If differences between wing morph accounted for heritable variation this would be reflected in a significant difference between heritability estimates for corrected data (for wing morph) and the unmodified data. The adjusted heritability estimates agree with the uncorrected estimates (Table II, III). Therefore, the significant heritabilities are not due to differences in wing morph. The corrected

heritability estimates for morphological traits agree with the uncorrected estimates with one exception, the dam component estimate (h^2_D) increased for file length (Table III).

2 Phenotypic Correlation

2.1 Correlations between song components

The song components, chirp length (cl), pulse rate (pr), number of pulses per chirp (ppc), and pulse length (pl) are mathematically related according to the formula:

$$cl = [(1000/pr) * (ppc-1)] + pl \quad (\text{equation 1})$$

The examination of a simulated oscillogram of a single chirp helps illustrate how this formula was derived (Figure 1). Multiplying the intrachirp pulse period (pulse period(ms)=1000/pulse rate(#/s)) by the number of pulses minus one, would result in the chirp length minus one full pulse length. Simply by adding pulse length to the above determines the chirp length.

The above relationship suggests that these components will be correlated in the manner shown in the upper corner of Table IV. These predictions are generated by considering the effect of varying only two parameters (pairwise analysis). However, a strong correlation between two parameters may reverse the sign of the predicted correlation between parameters (see Discussion).

Chirp length is positively correlated with the number of pulses per chirp and pulse length, and negatively correlated with pulse rate (Table IV). These correlations are as predicted, but the remaining are all opposite in sign to those predicted by a pairwise analysis.

2.2 Correlations between morphology and song components

Both the number of pulses per chirp and frequency are significantly negatively correlated with femur length (Table V). However, neither correlation would remain significant if the significance level is corrected for the total number of tests (Bonferroni-adjustment), and it is therefore unlikely that the calling song could be used by *G. firmus* females to assess male body size.

There is a low positive correlation between file length and pulse length (Table V). The reason for such a low correlation may be a consequence of differences between males in the portion of the file struck (see Discussion).

Carrier frequency is determined by the number of teeth struck per unit time (Koch et al 1988). Regression analysis of tooth number (tth) on file length (fil) indicates that the expected number of stridulatory teeth per unit length of file (file length/tooth number) decreases with increasing file length ($n=320$, multiple $r=0.50$, $P<0.001$):

$$tth = 119 + 16.7fil$$

Fewer teeth per unit length on the part of the file engaged during song production should result in a negative correlation between file length and frequency, if the speed of wing closure is constant. There is a weak nonsignificant negative correlation between frequency (f) and file length (fil) (Table V).

File length (fil) and resonator (res) area are weakly correlated with the number of pulses per chirp (ppc) (Table V). Although there is no mechanical reason to expect these correlations, they may be explained by energetic costs (see Discussion).

2.3 Variations in morphology between wing morphs.

Macropterous individuals have significantly longer files and larger resonator areas than micropterous individuals, but do not differ in either femur length or tooth number (Table VI). Intermediate individuals are omitted from the analysis as they comprise too small a sample size for statistically meaningful comparisons.

Of particular interest is the difference in overall morphology between micropterous and macropterous individuals. Not only do the lengths of the flight wings differ, but the morphology of the tegmina and the correlations between the morphology of the song producing structures and body size differ. Covariance analysis indicates that file length (fil) depends upon both morph and femur length (fem) ($n=312$, F-ratios: (morph)=139.626, $P<0.001$; (fem)=214.336, $P<0.001$). For a given femur length micropterous individuals have smaller file lengths:

$$\text{fil} = 1.4 + 0.23D + 0.21\text{fem}$$

where $D=0$ for microptery and $D=1$ for macroptery.

Similarly, for a given femur length (fem) micropterous individuals have smaller resonator areas (res) ($n=311$, F-ratios: (morph)=173.781, $P<0.001$; (fem)=161.590, $P<0.001$):

$$\text{res} = -1.2 + 0.74D + 0.51\text{fem}$$

where D is as above.

The morphs differ significantly in file length for a given body size (above), but do not differ significantly in the number of stridulatory teeth (tth) (see Table VI). This

accounts for the observed significant difference in the number of teeth for a given file length. Micropterous males have more teeth than macropterous males for a given file length (fil) (n=312, F-ratios: (morph)=29.816, $P<0.001$; (fil)=139.439, $P<0.001$):

$$tth = 103 - 5.0D + 21.0fil$$

where D is as above.

There is no significant difference between morphs in the mean number of stridulatory teeth. This, combined with a difference in file length, accounts for the significant difference in the number of stridulatory teeth (tth) for a given file length (fil) between morphs (n=312, F-ratios: (morph)=29.816, $P<0.001$; (fil)=139.439, $P<0.001$):

$$tth = 103 - 5.0D + 21.0fil$$

Can song be used to distinguish between wing morphs? Only pulse length differs significantly between morphs (Table VI). However, there is considerable overlap between morphs (Micropterous range=13.5-30.9, mean=23.3 \pm 3.0 (S.D.); Macropterous range=18.1-37.8, mean=26.1 \pm 3.5), making pulse length a poor predictor of wing morph. The smaller file lengths of micropterous males does not, alone, account for the shorter pulse lengths. There is a significant difference in pulse length for a given file length. Pulse length (pl) is related to wing morph (D) and file length (fil) according to:

$$pl = 17 + 2.5D + 1.6fil$$

However, the effect of file length (fil) is not significant (n=166, F-ratios: (wing)=18.657, $P<0.001$; (fil)=1.957, $P=0.164$). The difference in pulse length for a given file

length may be related to the difference in body size
(examined later) .

DISCUSSION

Morphological features typically possess higher heritabilities than behavioural traits (Mousseau and Roff 1987; Roff and Mousseau 1987). This general observation is supported by the present analysis, the heritabilities for the morphological features, $h^2_{S+D}=0.42$ to 0.73 , being significantly higher than the song components, $h^2_{S+D}=0.10$ to 0.35 (Table II). All of the morphological features show significant additive genetic variation, while only the heritability of one of the song components, pulse rate, is significant. However, it would be premature to assume that the heritabilities of the other song components are zero, as the standard errors are relatively large, though approximately equal to those of the morphological features. If we assume the heritability estimates are not zero, and estimate heritability to be 0.20 (approximately the mean h^2_{S+D} of the non-significant estimates), then the required family size for significance to be detected may be determined. The expected intraclass correlation for half sibs is $t=h^2/4$ (Robertson 1959, 1960; Falconer 1981), and the required intraclass correlation is $t=0.05$. The optimal number of offspring per dam is determined by $n=1/(2*t)$ (Robertson 1959), resulting in $n=10$. A mean of 5.3 (S.D.= 2.0) offspring per dam family was measured. Therefore, doubling the sample size (10 offspring per family) should result in significant heritability estimates for the song components if our assumption, that heritability is 0.20 , is correct.

The calling songs of crickets play an important role in species recognition and female phonotaxis (Walker 1957; Popov et al 1974; Popov and Shuvalov 1977; Pollack and Hoy 1981; Weber et al 1981; Pollack 1982; Thorson et al 1982; Stout et al 1983; Doherty 1985a, b), and are, therefore, expected to be under stabilizing selection. The structures

associated with sound production should also undergo stabilizing selection (Butlin and Hewitt 1986). The number of genes influencing these traits is unknown; however, the calling songs of crickets are known to be polygenic (Bentley 1971; Bentley and Hoy 1972). Characters undergoing stabilizing selection are expected to possess less variation than other traits (Butlin and Hewitt 1986). But, females may evaluate songs differently (i.e. have a different hierarchy of preferred song components (Doherty and Hoy 1985)), a behaviour which could contribute to the maintenance of genetic variation in the calling song.

Femur length, an index of body size, has a high heritability (Table II). File length and tooth number, closely associated with important features of the calling song, possess lower heritabilities than the resonator area, which is associated with song intensity (Michelsen and Nocke 1974). Song intensity, however, may not be of importance in female choice (Simmons 1988b). Trade-offs between traits chosen by females may contribute to the genetic variation in these traits. For example, femur length may be undergoing directional selection, with larger males being favored by females (Simmons 1987). But the song components important in species recognition and female phonotaxis, and their associated structures, may be under stabilizing selection. As the song producing structures and body size are correlated (Table V), changes in one may affect others and in turn influence calling song. Thus at some point trade-offs may occur between preferred song components and body size, contributing to the maintenance of genetic variation in the calling song.

Chirp length is positively correlated with the number of pulses per chirp and pulse length, and negatively correlated with pulse rate. These correlations are as predicted, but the remaining correlations are all opposite

in sign to that predicted by the pairwise analysis. This can be explained by the dominating influence of correlations with chirp length (cl). For example, consider the correlation between pulse length (pl) and the number of pulses per chirp (ppc). Rearranging equation 1 gives

$$pl = cl - (1000/pr) (ppc-1)$$

A simple pairwise analysis suggests that the number of pulses per chirp and pulse length will be negatively correlated. But, chirp length and the number of pulses per chirp are strongly positively correlated. Therefore, an increase in the number of pulses per chirp is accomplished by an increase in chirp length; if the latter increase exceeds the increase in the number of pulses per chirp, then pulse length will increase, not decrease. A significant positive correlation between pulse length and the number of pulses per chirp is, in fact, observed.

Female *Gryllus bimaculatus* prefer larger males, and there exists the possibility that the calling song, used to attract females, could contain information about the size of the advertiser (Simmons 1987, 1988a, 1988b). Simmons (1988b) found a significant increase in pulse rate and a decrease in chirp length with increasing body size (with pronotum width used as the index of body size) for *Gryllus bimaculatus*. The reduction in chirp length was attributed to a negative correlation in pulse rate. Pulse rate was determined to be unaffected by distance degradation, suggesting females could detect differences in pulse rate between males (Simmons 1988b). In *G. firmus* there is no significant correlation between pulse rate and femur length (used as the index of body size). Only the number of pulses per chirp and frequency form weak negative correlations ($n=162$; $r=-0.17$, $P<0.05$, and $r=-0.19$, $P<0.05$ respectively) with femur length, and are, therefore, not likely to be used by females to

assess body size. The use of pronotum width, as Simmons(1988b) employed, instead of femur length, would not alter the results for *G.firmus*, as there is a highly significant positive correlation between femur length and pronotum width for *G.firmus* ($n=106$, $r=0.77$, $P<0.001$ (Roff in progress)).

Pulse length is determined by the length of time the stridulatory file is engaged by the scraper upon wing closure. During calling song production, approximately one third of the file is engaged by the scraper (Rakshpal 1960). If this proportion is constant, the portion of file struck should increase with increasing file length. Given this, pulse length will be positively correlated with file length. Though positive, the correlation between pulse length and file length is not significant. Males with longer files possess more stridulatory teeth, though fewer teeth per unit length than males with shorter files, and there is a significant positive correlation between file length and femur length (the index of body size). This suggests that the teeth of larger males are larger and there is a greater intertooth distance than on the files of their smaller conspecifics. Larger teeth could, in theory, produce more drag during stridulation; however this should be overcome by the larger muscles of the larger males, resulting in little or no reduction in the speed of wing closure. If the relative portion of file engaged in song production were to vary between males, with larger males tending to engage a relatively smaller portion of the file (discussed later), then this would result in a weakened correlation between pulse length and femur length.

Larger males possess larger tegmina (tegmina structures are positively correlated with femur length, see table V), which may be heavier, have larger teeth (possibly creating more drag during stridulation), and are, therefore, likely

to be more energetically costly to move during song production. The cost of larger size, possibly preferred by females, may be lowered by a slight reduction in the number of pulses per chirp, as the cost of song production is related to the number of pulses produced per unit time (Prestwich and Walker 1981). This is supported by the observation that the number of pulses per chirp is negatively correlated with femur length, resonator area, and file length.

Micropterous and macropterous individuals differ not only in the length of their flight wings, but in their overall morphology. Micropterous individuals possess significantly shorter files, and smaller resonator areas, but do not differ in either femur length or tooth number, from macropterous males. For a given femur length, micropterous individuals possess significantly shorter files, and smaller resonator areas. There is no significant difference in mean tooth number between morphs, which, combined with a difference in file length, accounts for the significant difference in the number of teeth for a given file length. Micropterous individuals possess more teeth than macropterous individuals with the same file length, though, the difference is small (5 teeth). Carrier frequency, determined by the number of teeth struck per unit time, should differ between morphs if the number of teeth struck differs but the speed of wing closure does not differ. However, no significant difference in frequency was observed for a given file length. It is, therefore, unlikely that such a small difference in the number of teeth has any measurable effect on the speed of wing closure, or on the carrier frequency.

Pulse length differs significantly between wing morphs. The significantly smaller file lengths, of micropterous individuals, does not, alone, account for the significantly

smaller pulse lengths, as micropterous individuals have significantly shorter pulse lengths for a given file length. If micropterous and macropterous individuals possessing the same file length engage different relative portions of the file during song production, this could account for differences in pulse length, between morphs, for a given file length. For a given body size (as determined by femur length) micropterous individuals possess smaller files and resonator areas, suggesting the tegmina are smaller. It may be possible that a micropterous individual's larger body size, relative to tegminal size, could restrict the closing movement of the tegmina (how much of the file can be struck) during stridulation. The tegmina are held at an angle of 30-45° from the back during calling song production (Rakshpal 1960; Cade and Wyatt 1984). Rakshpal (1960) artificially manipulated the tegmina (*Acheta assimilis* and *A. veletis*) at the angle observed during calling, and produced a sound typical of a calling song pulse. In so doing, Rakshpal (1960) found that the scraper of the lower tegmen could not move beyond about 1/3 the length of the file of the uppermost tegmen, as observed when males call naturally. However, it may be possible that individuals vary slightly in how much of the file may be engaged by the scraper, with larger body size relative to tegmen size restricting tegminal movement more than a smaller body size relative to tegminal size. Micropterous individuals with the same femur length as macropterous individuals, but having shorter file lengths and smaller resonator areas (smaller tegmina relative to body size), may use a slightly smaller portion of the file, accounting for the observed difference in pulse lengths.

Rakshpal (1960) determined that only about 1/3 of the file is struck during calling song production; why then are there so many teeth, and why is the file so long? When Rakshpal (1960) held the tegmina parallel to the back, as

opposed to 30-45° from the back, they could be moved beyond the point typical of calling, but an "atypical" (...from the calling song pulse...) sound was produced on both the inward and outward stroke (calling song pulses are produced on the inward stroke only; Alexander 1961; Dambach and Rausche 1985). In the production of the courtship song, the tegmina are typically held parallel to the back (Alexander 1957; personal observation) with sounds, often much "softer" than the calling song, produced in both the inward and outward strokes (see Alexander 1961). Perhaps the "atypical" sound Rakshpal (1960) heard when holding the tegmina parallel to the back, and, hence, utilizing more of the file, was actually typical of the courtship song. Courtship may also be an important mechanism by which species discrimination, by females, may occur (Crankshaw 1979). The species specific courtship song is required by females of some species to mate (Burk 1982; Crankshaw 1979). A possible function of the "excess" teeth on the stridulatory file may lie in the production of the courtship song.

Phenotypic correlations between song and morphology suggest that changes in one may result in changes in the other. This is contingent on the genetic correlations between the traits; accurate estimates of these require more accurate estimates of the heritabilities of the song components. Differences in the tegminal morphology of micropterous and macropterous individuals resulted in measurable differences in the calling song. It is not unreasonable to expect morphological changes in the sound producing structures accompanied by changes in the calling song with selection on wing morph. Further research, however, is required to determine whether such variation in song could influence mate choice by females.

Table I. Character means, standard deviations (SD), minimum (MIN), and maximum (MAX) values, coefficient of variation (CV). Sample sizes for morphological features, n=320 (n=319 for resonator area). Sample sizes for song characters, n=170 (n=163 for frequency).

| Character | Mean | SD | MIN | MAX | CV(%) |
|-----------------------------|------------|----|-------|-------|-------|
| Morphological | | | | | |
| Femur length(mm) | 12.8±0.7 | | 10.8 | 14.6 | 5 |
| File length(mm) | 4.1±0.3 | | 3.4 | 5.0 | 7 |
| Res. area(mm ²) | 5.7±0.7 | | 3.6 | 7.6 | 12 |
| Tooth no. | 188.5±8.4 | | 160 | 210 | 4 |
| Song | | | | | |
| Pulses/chirp | 3.7±0.3 | | 3.1 | 4.3 | 8 |
| Pulse length(ms) | 24.6±3.5 | | 13.5 | 37.8 | 14 |
| Pulse rate(pulses/s) | 20.9±1.9 | | 17.3 | 26.1 | 9 |
| Chirp length(ms) | 153.7±18.8 | | 115.8 | 203.9 | 12 |
| Frequency(kHz) | 4.0±0.2 | | 3.7 | 4.6 | 5 |

Table II. Heritability estimates and their standard errors.
 fem=femur length; fil=file length; res=resonator area;
 tth=stridulatory tooth number; ppc=number of pulses per
 chirp; pl=pulse length; pr=pulse rate; cl=chirp length;
 f=carrier frequency.

| Heritabilities | | | |
|----------------------|-------------|------------|-------------|
| CHARACTER | h^2_S | h^2_D | h^2_{S+D} |
| Morphological | | | |
| fem | 0.26±0.29 | 1.01±0.36* | 0.64±0.19* |
| fil | 0.67±0.40 | 0.42±0.20* | 0.55±0.21* |
| res | 0.62±0.43 | 0.85±0.31* | 0.73±0.24* |
| tth | 0.18±0.21 | 0.65±0.27* | 0.42±0.14* |
| Song | | | |
| ppc | -0.28±0.10* | 0.66±0.39 | 0.19±0.15 |
| pl | 0.23±0.22 | 0.22±0.26 | 0.22±0.15 |
| pr | 0.18±0.24 | 0.52±0.33 | 0.35±0.17* |
| cl | -0.15±0.12 | 0.61±0.37 | 0.23±0.15 |
| f | 0.02±0.14 | 0.18±0.28 | 0.10±0.13 |

* $P < 0.05$

Table III. Heritability estimates and their standard errors after adjusting for wing morph.

| Heritabilities | | | |
|----------------------|-------------|------------|-------------|
| CHARACTER | h^2_S | h^2_D | h^2_{S+D} |
| Morphological | | | |
| Femur length | 0.22±0.27 | 1.04±0.36* | 0.63±0.19* |
| File length | 0.35±0.29 | 0.72±0.28* | 0.54±0.18* |
| Res. area | 0.11±0.22 | 1.02±0.36* | 0.57±0.17* |
| Tooth no. | 0.17±0.21 | 0.66±0.27* | 0.41±0.14* |
| Song | | | |
| Pulses/chirp | -0.28±0.10* | 0.66±0.39 | 0.19±0.15 |
| Pulse length | 0.17±0.19 | 0.10±0.24 | 0.14±0.13 |
| Pulse rate | 0.15±0.22 | 0.50±0.33 | 0.32±0.16* |
| Chirp length | -0.17±0.12 | 0.62±0.37 | 0.22±0.15 |
| Frequency | -0.08±0.11 | 0.24±0.30 | 0.08±0.12 |

* $P < 0.05$

Table IV. Partial correlation, on wing morph (micropterous and macropterous individuals), matrix of song components on song components. Sample size is 163. Probability levels are not Bonferroni-adjusted. Predicted correlations from a "pairwise" analysis are shown in the upper triangle. ppc=number of pulses per chirp; pl=pulse length; pr=pulse rate; cl=chirp length; f=carrier frequency.

| | ppc | pl | pr | cl |
|-----|---------|----------|----------|----------|
| ppc | | - | + | + |
| pl | 0.30*** | | + | + |
| pr | -0.10 | -0.48*** | | - |
| cl | 0.77*** | 0.59*** | -0.66*** | |
| f | -0.11 | -0.33*** | 0.40*** | -0.35*** |

*** $P < 0.001$

Table V. Partial correlation, on wing morph. The sample size, n, for morphological features on morphological features is n=319; for morphological features on song components n=162. Probability levels are not Bonferroni-adjusted. fem=femur length; fil=file length; res=resonator area; tth=stridulatory tooth number; ppc=number of pulses per chirp; pl=pulse length; pr=pulse rate; cl=chirp length; f=carrier frequency.

| | fem | fil | res | tth |
|-----|---------|---------|---------|-------|
| fil | 0.64*** | | | |
| res | 0.59*** | 0.63*** | | |
| tth | 0.32*** | 0.56*** | 0.33*** | |
| ppc | -0.17* | -0.18* | -0.19* | -0.03 |
| pl | 0.03 | 0.12 | 0.07 | 0.06 |
| pr | -0.02 | 0.09 | -0.01 | 0.10 |
| cl | -0.08 | -0.15 | -0.11 | -0.06 |
| f | -0.19* | -0.07 | -0.07 | -0.11 |

*P<0.05; ***P<0.001

Table VI. Character means, standard deviations (SD) by wing morph: SW=micropterous; LW=macropterous. Sample sizes for morphological features for micropterous individuals, n=176 (n=175 for resonator area); macropterous, n=136. Sample sizes for song characters: micropterous, n=89 (n=85 for frequency); macropterous, n=77 (n=75 for frequency). P=probability level of ANOVA by wing morph.

| Character | SW | | LW | | P |
|------------------------------|------------|----|------------|----|--------|
| | Mean | SD | Mean | SD | |
| Morphological | | | | | |
| Femur length (mm) | 12.8±0.8 | | 12.9±0.6 | | 0.210 |
| File length (mm) | 4.0±0.2 | | 4.3±0.2 | | <0.001 |
| Res. area (mm ²) | 5.3±0.6 | | 6.1±0.6 | | <0.001 |
| Tooth no. | 188.4±8.5 | | 188.7±8.4 | | 0.748 |
| Song | | | | | |
| Pulses/chirp | 3.7±0.3 | | 3.7±0.3 | | 0.933 |
| Pulse length (ms) | 23.3±3.0 | | 26.1±3.5 | | <0.001 |
| Pulse rate (pulses/s) | 21.0±1.8 | | 20.8±1.9 | | 0.503 |
| Chirp length (ms) | 153.0±18.4 | | 154.8±19.7 | | 0.558 |
| Frequency (kHz) | 4.0±0.2 | | 4.0±0.2 | | 0.822 |

FIGURES

Figure 1. Simulated oscillogram of one chirp of a *G. firmus* calling song. Measurements made are averages for all chirps and pulses.

Figure 2. Right tegmen of *G. firmus*, ventral view. Most of the lateral part, L, of the tegmen removed. A, stridulatory vein, the part of vein A having teeth is considered the stridulatory file; R, resonator (shaded region); H, harp (shaded region).

Figure 3. Modified petri dish cage. The bottom of petri dish 1 and the top of petri dish 2 are fused, forming the floor of the cage. The lid of the cage is the lid of petri dish 1. The water reservoir is in the bottom of petri dish 2.

Figure 1

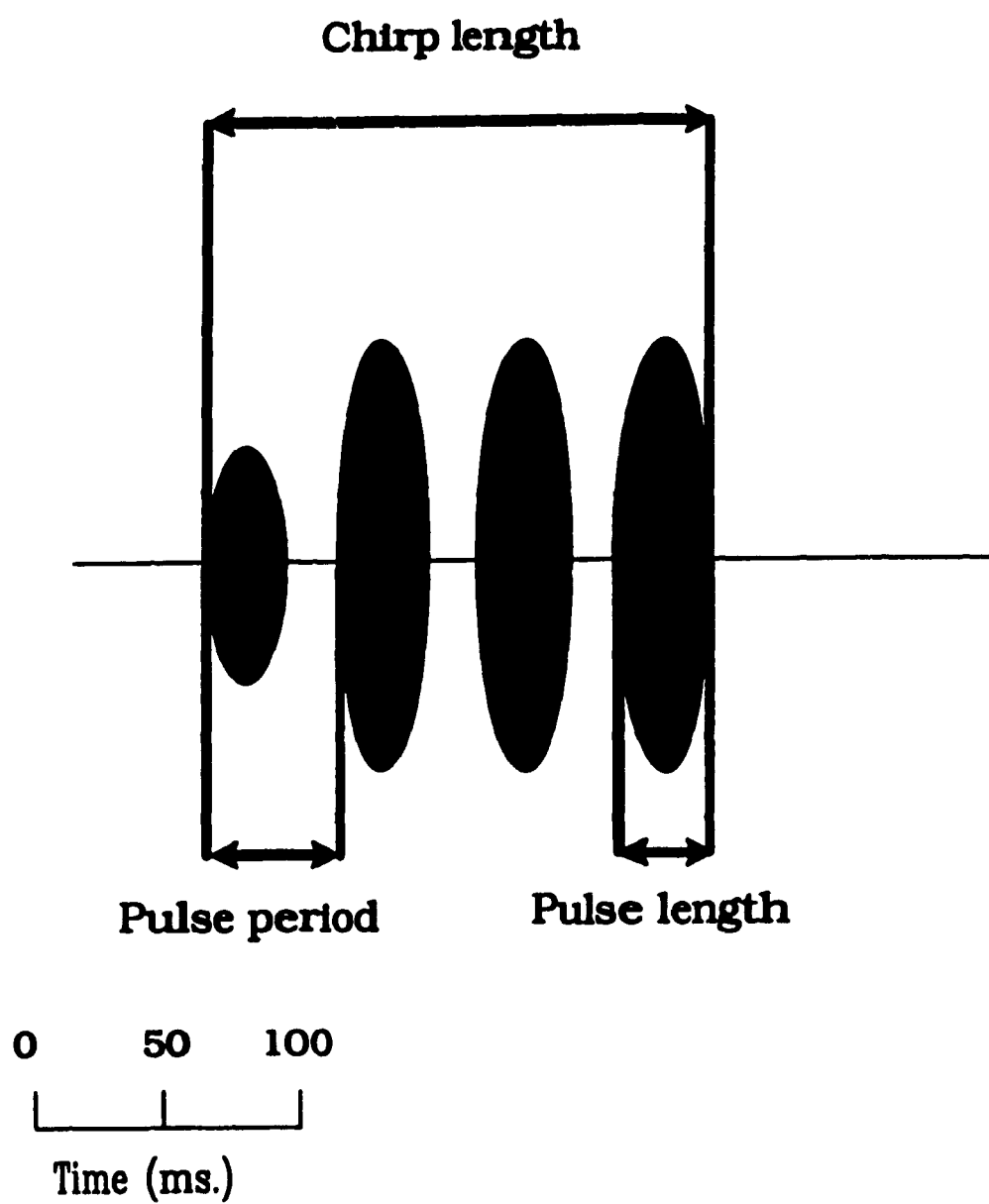


Figure 2

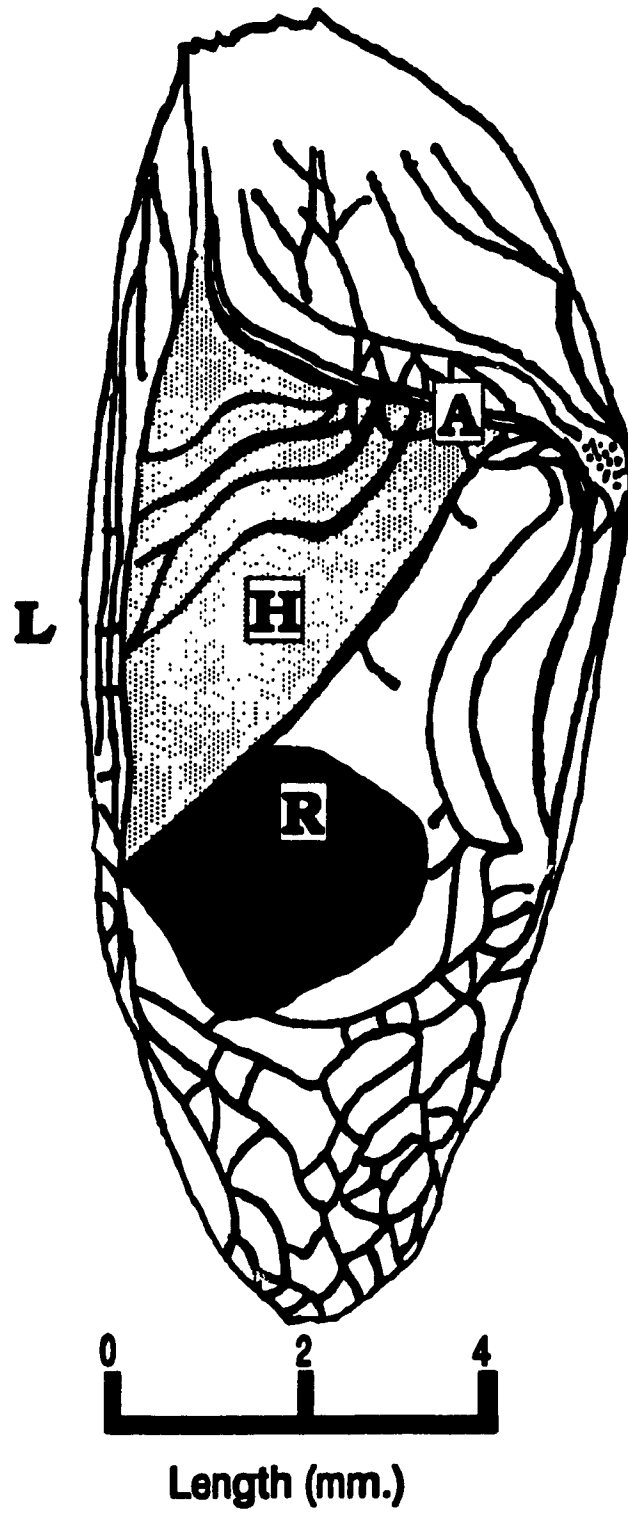
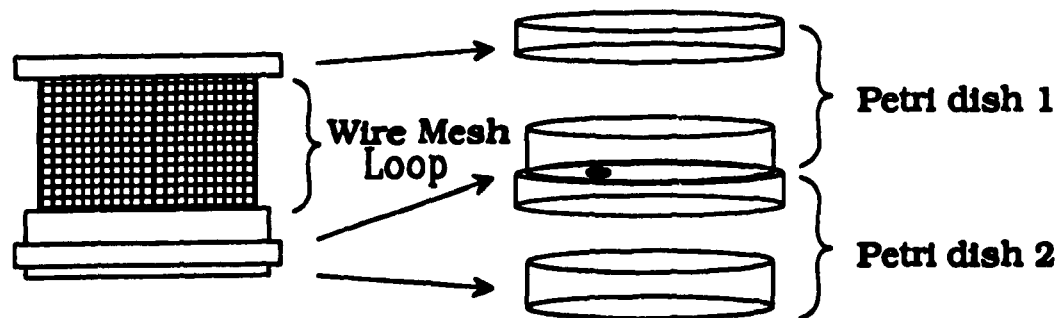


Figure 3



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APPENDIX 1

As communicated by:

**Tom MacDonald
Dept. of Biological Sciences,
Technical services-electronics
Brock University
St. Catharines, Ontario
Canada, L2S 3A1**

**EQUIPMENT USED: BROCK UNIVERSITY DIGITAL SIGNAL PROCESSING
NETWORK**

THE SYSTEM CONSISTS OF:

- 1) 6 channel CPU controlled data acquisition module
Input sensitivity- 16 BIT A/D
Onboard 10kHz active filter on each channel**
- 2) CPU controlled X/Y monitor display driver for real
time data display**
- 3) VAP 64K digital array processing board
-performs fourier transform calculation real-time
(40kHz)
-16 BIT resolution in fourier calculations**
- 4) CPU host process control to IBM computer for setup and
control of DSP application programs.**

APPLICATION PROGRAMS USED:

- 1) Pulse duration measurement: this function invokes real
time analysis of variations in cricket song pulse period,
pulse length, pulses/chirp, chirp length and inter-chirp
duration. The input signal from the tape recording is first
rectified and then filtered to condition the signal for
pulse envelope measurement. This function plots the**

frequency of occurrence of the above parameters on a X/Y axis.

2) Fourier transform integrated: this function performs real time 5 second integrated 1k point fourier transform on the input signal. Frequency bandwidth is equal to

$$(1/\text{sample rate})/2$$

Eg. 50us sample rate = 10kHz bandwidth

resolution = $10\text{kHz}/512 = 0.019 \text{ Hz/bin}$ (512 frequency bins)

APPENDIX II

The following is a table of the experimental raw data.
m=male number; w=wing morph (0=micropteroous,
1=macropteroous, and 2=intermediate); S=sire number; D=dam
number (1-4 for each sire); fem=femur length(mm); fil=file
length(mm); res=resonator area(mm²); tth=number of
stridulatory teeth; #c=number of chirps analyzed;
ppc=number of pulses per chirp; pl=pulse length(ms);
pr=pulse rate(#pulses/s); cl=chirp length(ms); and
f=carrier frequency(kHz) .

| m | w | S | D | fem | fil | res | thh | #c | ppc | pl | pr | cl | f |
|----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 1 | 0 | 1 | 1 | 13.44 | 3.9 | 5.6 | 165 | 108 | 3.5 | 24.0 | 18.8 | 153.4 | 3.9 |
| 2 | 0 | 1 | 1 | 13.26 | 4.1 | 5.7 | 186 | 142 | 3.2 | 24.9 | 21.1 | 128.6 | 3.9 |
| 3 | 0 | 1 | 1 | 13.85 | 4.2 | 5.7 | 183 | 149 | 3.6 | 21.6 | 20.3 | 147.5 | 3.8 |
| 4 | 0 | 1 | 1 | 14.40 | 4.4 | 6.4 | 182 | | | | | | |
| 5 | 1 | 1 | 1 | 12.54 | 4.1 | 5.9 | 171 | 188 | 4.3 | 30.7 | 19.0 | 203.9 | 3.9 |
| 6 | 1 | 1 | 1 | 12.38 | 4.4 | 6.4 | 172 | 424 | 3.8 | 27.9 | 19.1 | 164.2 | 3.7 |
| 7 | 1 | 1 | 1 | 13.27 | 4.1 | 6.7 | 173 | 214 | 3.5 | 26.2 | 18.1 | 159.0 | 3.9 |
| 8 | 1 | 1 | 1 | 13.04 | 4.1 | 6.1 | 173 | | | | | | |
| 9 | 1 | 1 | 1 | 13.20 | 4.1 | 6.4 | 169 | 875 | 3.6 | 24.6 | 18.6 | 159.5 | 3.9 |
| 10 | 1 | 1 | 1 | 13.88 | 4.4 | 6.6 | 186 | | | | | | |
| 11 | 0 | 1 | 2 | 13.76 | 4.3 | 5.7 | 189 | | | | | | |
| 12 | 0 | 1 | 2 | 12.25 | 4.1 | 4.7 | 182 | 106 | 4.0 | 22.1 | 17.6 | 187.5 | 4.0 |
| 13 | 0 | 1 | 2 | 12.54 | 4.2 | 5.2 | 188 | 148 | 3.7 | 28.0 | 22.0 | 149.7 | 4.1 |
| 14 | 0 | 1 | 2 | 12.44 | 4.0 | 4.7 | 191 | | | | | | |
| 15 | 0 | 1 | 2 | 12.43 | 4.0 | 5.1 | 180 | | | | | | |
| 16 | 0 | 1 | 2 | 12.48 | 4.0 | 5.2 | 183 | | | | | | |
| 17 | 0 | 1 | 2 | 12.52 | 4.0 | 4.8 | 176 | 399 | 3.9 | 26.5 | 19.3 | 167.4 | 4.0 |
| 18 | 1 | 1 | 2 | 12.80 | 4.6 | 6.9 | 194 | 163 | 3.4 | 27.6 | 19.0 | 149.2 | 4.1 |
| 19 | 1 | 1 | 2 | 12.57 | 4.4 | 6.2 | 183 | | | | | | |
| 20 | 1 | 1 | 2 | 12.93 | 4.5 | 6.7 | 182 | 196 | 3.6 | 24.2 | 23.2 | 137.3 | 3.9 |
| 21 | 0 | 1 | 3 | 13.80 | 4.1 | 5.9 | 184 | 92 | 3.6 | 21.5 | 23.1 | 132.7 | 3.9 |
| 22 | 0 | 1 | 3 | 13.69 | 4.2 | 6.0 | 193 | | | | | | |
| 23 | 0 | 1 | 3 | 14.55 | 4.5 | 6.4 | 202 | | | | | | |
| 24 | 0 | 1 | 3 | 14.44 | 4.1 | 5.4 | 186 | | | | | | |
| 25 | 0 | 1 | 3 | 13.61 | 4.0 | 5.7 | 183 | 104 | 3.7 | 26.3 | 19.3 | 167.0 | 3.8 |
| 26 | 0 | 1 | 3 | 14.05 | 4.3 | 5.4 | 193 | | | | | | |
| 27 | 0 | 1 | 3 | 13.40 | 4.2 | 6.1 | 188 | 53 | 4.0 | 26.9 | 21.1 | 173.9 | 3.8 |
| 28 | 0 | 1 | 3 | 13.94 | 4.3 | 6.1 | 197 | 105 | 3.7 | 24.3 | 20.0 | 151.0 | 3.8 |
| 29 | 0 | 1 | 3 | 13.73 | 4.1 | 6.2 | 185 | 167 | 3.5 | 22.7 | 20.5 | 142.6 | 4.0 |
| 30 | 1 | 1 | 3 | 13.75 | 4.6 | 6.7 | 195 | | | | | | |
| 31 | 0 | 1 | 4 | 12.32 | 4.0 | 5.8 | 185 | | | | | | |
| 32 | 0 | 1 | 4 | 13.80 | 4.5 | 6.4 | 200 | | | | | | |
| 33 | 1 | 1 | 4 | 13.27 | 4.5 | 6.6 | 187 | 123 | 3.7 | 23.7 | 19.2 | 150.9 | 4.1 |
| 34 | 1 | 1 | 4 | 12.10 | 4.1 | 6.0 | 182 | 162 | 3.6 | 28.0 | 20.0 | 156.5 | 4.0 |
| 35 | 1 | 1 | 4 | 12.84 | 4.3 | 6.1 | 186 | 125 | 3.7 | 24.1 | 21.1 | 150.0 | 3.9 |
| 36 | 1 | 1 | 4 | 13.65 | 4.6 | 6.0 | 199 | | | | | | |
| 37 | 1 | 1 | 4 | 13.79 | 4.6 | 6.5 | 200 | | | | | | |
| 38 | 1 | 1 | 4 | 13.72 | 4.2 | 6.1 | 183 | | | | | | |
| 39 | 1 | 1 | 4 | 12.77 | 4.2 | 5.8 | 190 | 188 | 3.6 | 29.3 | 17.6 | 163.5 | 4.0 |
| 40 | 1 | 1 | 4 | 13.18 | 4.6 | 6.6 | 189 | | | | | | |
| 41 | 0 | 2 | 1 | 11.46 | 3.8 | 4.3 | 193 | 188 | 3.4 | 25.0 | 18.1 | 153.5 | 4.0 |
| 42 | 0 | 2 | 1 | 12.09 | 3.9 | 4.7 | 174 | | | | | | |
| 43 | 0 | 2 | 1 | 11.69 | 3.7 | 4.3 | 187 | | | | | | |
| 44 | 0 | 2 | 1 | 11.90 | 3.9 | 4.6 | 184 | 161 | 3.8 | 24.1 | 21.4 | 161.9 | 4.2 |
| 45 | 0 | 2 | 1 | 11.94 | 3.7 | 4.8 | 178 | | | | | | |
| 46 | 0 | 2 | 1 | 12.70 | 4.1 | 4.9 | 193 | | | | | | |

| m | w | S | D | fem | fil | res | tth | #c | ppc | pl | pr | cl | f |
|----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 47 | 0 | 2 | 1 | 12.16 | 3.9 | 4.5 | 182 | | | | | | |
| 48 | 0 | 2 | 1 | 12.15 | 3.7 | 4.4 | 179 | | | | | | |
| 49 | 0 | 2 | 1 | 10.76 | 3.5 | 4.1 | 174 | | | | | | |
| 50 | 0 | 2 | 1 | 10.91 | 3.5 | 3.6 | 185 | | | | | | |
| 51 | 0 | 2 | 2 | 12.88 | 3.9 | 5.7 | 189 | | | | | | |
| 52 | 0 | 2 | 2 | 13.04 | 3.9 | 5.3 | 189 | | | | | | |
| 53 | 0 | 2 | 2 | 12.07 | 4.2 | 5.6 | 193 | 159 | 3.3 | 13.6 | 22.0 | 123.3 | 4.5 |
| 54 | 0 | 2 | 2 | 12.97 | 3.8 | 4.8 | 189 | 130 | 3.4 | 22.0 | 20.5 | 140.4 | 3.8 |
| 55 | 0 | 2 | 2 | 13.23 | 4.0 | 6.3 | 181 | | | | | | |
| 56 | 0 | 2 | 2 | 11.86 | 3.9 | 4.9 | 180 | 136 | 4.1 | 23.6 | 22.9 | 164.3 | 3.9 |
| 57 | 0 | 2 | 2 | 13.07 | 4.0 | 6.1 | 173 | 164 | 3.2 | 25.7 | 21.1 | 126.5 | 4.0 |
| 58 | 0 | 2 | 2 | 14.56 | 4.0 | 5.9 | 187 | | | | | | |
| 59 | 0 | 2 | 2 | 13.11 | 3.9 | 5.9 | 180 | 183 | 3.7 | 21.5 | 21.0 | 149.3 | 4.0 |
| 60 | 0 | 2 | 2 | 12.29 | 3.9 | 6.0 | 193 | | | | | | |
| 61 | 0 | 2 | 3 | 13.00 | 3.8 | 5.3 | 184 | | | | | | |
| 62 | 0 | 2 | 3 | 12.55 | 3.9 | 6.0 | 185 | | | | | | |
| 63 | 0 | 2 | 3 | 12.35 | 3.7 | 4.6 | 181 | | | | | | |
| 64 | 0 | 2 | 3 | 13.10 | 4.1 | 5.7 | 188 | | | | | | |
| 65 | 0 | 2 | 3 | 12.25 | 3.9 | 5.4 | 188 | | | | | | |
| 66 | 0 | 2 | 3 | 12.90 | 3.8 | 5.0 | 185 | 169 | 3.6 | 24.9 | 19.5 | 156.2 | 3.9 |
| 67 | 0 | 2 | 3 | 12.33 | 4.0 | 5.5 | 190 | | | | | | |
| 68 | 0 | 2 | 3 | 11.88 | 3.4 | 6.0 | 160 | | | | | | |
| 69 | 0 | 2 | 3 | 11.40 | 3.5 | 4.7 | 171 | | | | | | |
| 70 | 1 | 2 | 3 | 12.96 | 4.5 | 6.6 | 193 | | | | | | |
| 71 | 0 | 2 | 4 | 13.39 | 3.9 | 4.5 | 193 | | | | | | |
| 72 | 0 | 2 | 4 | 13.34 | 4.1 | 5.0 | 189 | | | | | | |
| 73 | 0 | 2 | 4 | 13.39 | 4.4 | 5.0 | 193 | 157 | 3.9 | 22.0 | 22.1 | 151.2 | 4.1 |
| 74 | 0 | 2 | 4 | 12.63 | 4.0 | 4.7 | 182 | | | | | | |
| 75 | 0 | 2 | 4 | 11.24 | 3.5 | 4.5 | 173 | | | | | | |
| 76 | 0 | 2 | 4 | 12.84 | 4.0 | 4.9 | 183 | 116 | 3.9 | 21.3 | 22.9 | 142.0 | |
| 77 | 0 | 2 | 4 | 12.76 | 4.0 | 5.4 | 183 | | | | | | |
| 78 | 0 | 2 | 4 | 13.35 | 4.1 | 4.9 | 182 | | | | | | |
| 79 | 0 | 2 | 4 | 12.95 | 3.9 | 5.0 | 188 | | | | | | |
| 80 | 0 | 2 | 4 | 12.38 | 4.1 | 4.6 | 181 | | | | | | |
| 81 | 0 | 3 | 1 | 12.49 | 4.1 | 5.5 | 182 | 115 | 3.3 | 19.9 | 22.4 | 120.0 | 4.1 |
| 82 | 0 | 3 | 1 | 11.38 | 3.9 | 5.0 | 183 | 143 | 4.1 | 18.2 | 20.9 | 162.4 | 4.2 |
| 83 | 0 | 3 | 1 | 12.35 | 4.3 | 5.6 | 189 | 297 | 3.7 | 23.5 | 19.5 | 153.1 | 4.0 |
| 84 | 0 | 3 | 1 | 12.64 | 4.2 | 5.8 | 197 | 201 | 4.2 | 26.2 | 19.5 | 181.3 | 3.9 |
| 85 | 0 | 3 | 1 | 12.29 | 4.3 | 5.6 | 187 | 141 | 3.6 | 29.1 | 18.2 | 176.1 | 3.7 |
| 86 | 0 | 3 | 1 | 11.56 | 4.2 | 5.0 | 178 | 245 | 3.5 | 24.2 | 19.5 | 152.8 | 3.7 |
| 87 | 0 | 3 | 1 | 11.34 | 3.8 | 4.8 | 176 | 143 | 3.7 | 20.0 | 20.2 | 159.2 | 4.2 |
| 88 | 1 | 3 | 1 | 11.47 | 4.1 | 5.7 | 174 | 208 | 3.6 | 26.7 | 19.8 | 154.2 | 3.8 |
| 89 | 1 | 3 | 1 | 12.28 | 4.3 | 6.6 | 193 | 250 | 3.9 | 34.2 | 17.4 | 182.2 | 3.7 |
| 90 | 1 | 3 | 1 | 12.21 | 4.2 | 5.8 | 187 | 483 | 3.5 | 21.1 | 18.9 | 140.1 | 4.2 |
| 91 | 0 | 3 | 2 | 11.48 | 3.8 | | 177 | 98 | 3.9 | 23.6 | 23.7 | 144.4 | 4.6 |
| 92 | 0 | 3 | 2 | 12.59 | 3.9 | 4.3 | 190 | | | | | | |

| m | w | S | D | fem | fil | res | th | #c | ppc | pl | pr | cl | f |
|-----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 93 | 0 | 3 | 2 | 14.19 | 4.3 | 5.7 | 202 | 85 | 3.7 | 20.0 | 23.2 | 135.5 | 4.1 |
| 94 | 0 | 3 | 2 | 12.52 | 3.7 | 5.0 | 185 | 106 | 4.2 | 21.7 | 20.4 | 179.2 | 3.9 |
| 95 | 0 | 3 | 2 | 12.61 | 4.2 | 5.3 | 190 | 161 | 4.0 | 25.7 | 20.1 | 176.7 | 4.1 |
| 96 | 0 | 3 | 2 | 12.69 | 4.2 | 5.0 | 187 | 167 | 3.7 | 20.5 | 21.4 | 144.4 | |
| 97 | 0 | 3 | 2 | 13.25 | 4.3 | 5.9 | 199 | | | | | | |
| 98 | 0 | 3 | 2 | 13.21 | 4.0 | 5.6 | 192 | 258 | 3.7 | 24.3 | 17.7 | 175.3 | 3.7 |
| 99 | 1 | 3 | 2 | 11.39 | 3.9 | 4.8 | 178 | | | | | | |
| 100 | 1 | 3 | 2 | 13.32 | 4.6 | 6.6 | 196 | | | | | | |
| 101 | 0 | 3 | 3 | 13.43 | 4.4 | 6.0 | 197 | | | | | | |
| 102 | 0 | 3 | 3 | 12.72 | 3.9 | 5.2 | 185 | | | | | | |
| 103 | 0 | 3 | 3 | 13.13 | 4.0 | 5.4 | 178 | | | | | | |
| 104 | 0 | 3 | 3 | 12.08 | 3.8 | 4.7 | 191 | | | | | | |
| 105 | 0 | 3 | 3 | 13.26 | 4.0 | 4.8 | 182 | 153 | 3.4 | 22.1 | 19.0 | 143.8 | 3.9 |
| 106 | 0 | 3 | 3 | 12.75 | 4.0 | 5.1 | 184 | | | | | | |
| 107 | 0 | 3 | 3 | 11.30 | 3.8 | 4.7 | 172 | 199 | 3.9 | 25.8 | 19.7 | 163.1 | 4.1 |
| 108 | 1 | 3 | 3 | 13.31 | 4.4 | 6.1 | 189 | 125 | 3.4 | 26.2 | 24.5 | 124.4 | 4.2 |
| 109 | 1 | 3 | 3 | 13.33 | 4.6 | 6.9 | 183 | 132 | 3.2 | 26.3 | 22.9 | 118.3 | 4.3 |
| 110 | 1 | 3 | 3 | 12.57 | 3.8 | 6.1 | 172 | 116 | 3.9 | 23.3 | 20.7 | 160.7 | 4.3 |
| 111 | 0 | 3 | 4 | 12.56 | 4.1 | 5.8 | 199 | | | | | | |
| 112 | 0 | 3 | 4 | 12.69 | 4.1 | 5.8 | 191 | 150 | 3.6 | 13.5 | 24.4 | 119.4 | 4.0 |
| 113 | 0 | 3 | 4 | 13.54 | 4.1 | 6.2 | 192 | 164 | 3.5 | 19.3 | 21.2 | 136.0 | 4.1 |
| 114 | 0 | 3 | 4 | 12.48 | 4.1 | 5.4 | 182 | 90 | 3.4 | 16.3 | 22.2 | 125.0 | 4.0 |
| 115 | 0 | 3 | 4 | 13.07 | 3.9 | 5.2 | 184 | 185 | 4.0 | 20.1 | 21.7 | 158.6 | 4.0 |
| 116 | 1 | 3 | 4 | 12.73 | 4.6 | 6.5 | 202 | 125 | 4.2 | 37.8 | 23.5 | 163.5 | 4.0 |
| 117 | 1 | 3 | 4 | 12.84 | 4.3 | 6.4 | 181 | | | | | | |
| 118 | 1 | 3 | 4 | 13.14 | 4.1 | 5.6 | 197 | | | | | | |
| 119 | 1 | 3 | 4 | 12.32 | 4.5 | 6.6 | 201 | | | | | | |
| 120 | 1 | 3 | 4 | 13.58 | 4.6 | 6.9 | 205 | 142 | 3.4 | 23.3 | 22.5 | 131.2 | 3.9 |
| 121 | 0 | 4 | 1 | 13.53 | 4.3 | 6.4 | 194 | 154 | 3.8 | 24.9 | 18.7 | 171.2 | 3.8 |
| 122 | 0 | 4 | 1 | 13.55 | 4.3 | 6.2 | 210 | 95 | 3.4 | 24.6 | 21.0 | 133.0 | |
| 123 | 1 | 4 | 1 | 12.90 | 4.2 | 4.2 | 197 | 82 | 4.3 | 28.1 | 20.9 | 186.3 | 3.7 |
| 124 | 1 | 4 | 1 | 12.54 | 4.5 | 6.4 | 197 | | | | | | |
| 125 | 1 | 4 | 1 | 13.10 | 4.3 | 6.0 | 189 | 178 | 3.7 | 23.5 | 20.2 | 145.8 | 3.8 |
| 126 | 1 | 4 | 1 | 12.78 | 4.2 | 5.2 | 184 | 148 | 3.5 | 26.5 | 19.9 | 155.1 | 3.7 |
| 127 | 1 | 4 | 1 | 13.32 | 4.4 | 6.0 | 197 | 132 | 3.1 | 24.9 | 22.2 | 120.3 | 3.9 |
| 128 | 1 | 4 | 1 | 12.54 | 4.2 | 4.9 | 190 | 199 | 3.4 | 31.1 | 18.5 | 160.9 | 4.0 |
| 129 | 1 | 4 | 1 | 12.81 | 4.4 | 6.0 | 186 | | | | | | |
| 130 | 2 | 4 | 1 | 12.15 | 3.7 | 4.7 | 172 | 92 | 3.8 | 18.0 | 21.8 | 144.3 | 3.7 |
| 131 | 0 | 4 | 2 | 11.84 | 4.0 | 4.7 | 180 | | | | | | |
| 132 | 0 | 4 | 2 | 12.49 | 3.7 | 4.5 | 175 | 104 | 4.0 | 24.2 | 19.9 | 175.1 | |
| 133 | 0 | 4 | 2 | 12.67 | 4.1 | 5.4 | 201 | | | | | | |
| 134 | 0 | 4 | 2 | 13.29 | 4.4 | 6.0 | 189 | 201 | 4.0 | 28.9 | 20.9 | 162.8 | 3.9 |
| 135 | 0 | 4 | 2 | 12.16 | 3.6 | 4.1 | 168 | 126 | 3.9 | 19.9 | 26.1 | 131.4 | 4.4 |
| 136 | 0 | 4 | 2 | 12.12 | 3.7 | 5.0 | 179 | 88 | 4.2 | 25.8 | 21.7 | 170.1 | 4.0 |
| 137 | 1 | 4 | 2 | 12.80 | 4.2 | 5.5 | 179 | 138 | 4.1 | 25.2 | 22.5 | 169.8 | 4.0 |
| 138 | 1 | 4 | 2 | 12.93 | 4.2 | 5.4 | 182 | 120 | 4.2 | 28.6 | 21.4 | 187.0 | 3.9 |

| m | w | S | D | fem | fil | res | th | #c | ppc | pl | pr | cl | f |
|-----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 139 | 1 | 4 | 2 | 12.80 | 4.0 | 5.5 | 169 | | | | | | |
| 140 | 1 | 4 | 2 | 12.72 | 4.5 | 6.6 | 195 | | | | | | |
| 141 | 0 | 4 | 3 | 13.33 | 4.1 | 5.8 | 192 | 112 | 3.5 | 22.4 | 20.7 | 146.9 | 3.9 |
| 142 | 0 | 4 | 3 | 12.97 | 3.9 | 5.0 | 190 | | | | | | |
| 143 | 0 | 4 | 3 | 13.58 | 4.2 | 5.2 | 194 | | | | | | |
| 144 | 0 | 4 | 3 | 12.05 | 3.9 | 4.8 | 186 | 110 | 3.7 | 23.6 | 19.7 | 160.4 | 4.0 |
| 145 | 0 | 4 | 3 | 14.16 | 3.9 | 4.8 | 178 | | | | | | |
| 146 | 0 | 4 | 3 | 13.48 | 4.1 | 6.2 | 194 | | | | | | |
| 147 | 0 | 4 | 3 | 12.62 | 4.0 | 5.1 | 193 | 152 | 3.7 | 23.3 | 18.0 | 169.4 | 4.1 |
| 148 | 0 | 4 | 3 | 12.67 | 3.9 | 4.8 | 192 | 136 | 3.6 | 21.1 | 18.5 | 156.0 | 4.0 |
| 149 | 0 | 4 | 3 | 12.80 | 3.9 | 5.7 | 191 | | | | | | |
| 150 | 0 | 4 | 3 | 12.81 | 3.9 | 5.0 | 194 | | | | | | |
| 151 | 0 | 4 | 4 | 13.35 | 3.9 | 5.1 | 194 | | | | | | |
| 152 | 0 | 4 | 4 | 13.66 | 4.3 | 6.0 | 199 | | | | | | |
| 153 | 0 | 4 | 4 | 13.43 | 4.2 | 6.0 | 203 | | | | | | |
| 154 | 0 | 4 | 4 | 12.22 | 4.2 | 5.2 | 201 | 129 | 3.7 | 24.3 | 20.8 | 155.5 | 4.0 |
| 155 | 0 | 4 | 4 | 12.04 | 3.9 | 5.4 | 190 | | | | | | |
| 156 | 0 | 4 | 4 | 12.72 | 4.2 | 5.4 | 193 | 105 | 3.4 | 21.9 | 22.9 | 131.6 | 4.2 |
| 157 | 0 | 4 | 4 | 12.69 | 3.9 | 5.0 | 188 | | | | | | |
| 158 | 1 | 4 | 4 | 13.26 | 4.3 | 6.9 | 190 | | | | | | |
| 159 | 1 | 4 | 4 | 13.02 | 4.4 | 6.3 | 194 | | | | | | |
| 160 | 1 | 4 | 4 | 12.61 | 4.1 | 5.9 | 187 | | | | | | |
| 161 | 0 | 5 | 1 | 14.36 | 4.3 | 6.3 | 200 | | | | | | |
| 162 | 0 | 5 | 1 | 13.36 | 4.4 | 7.4 | 190 | 80 | 3.6 | 25.8 | 20.9 | 143.5 | 3.9 |
| 163 | 1 | 5 | 1 | 13.45 | 4.6 | 7.1 | 189 | 181 | 3.7 | 23.8 | 23.3 | 135.5 | 4.2 |
| 164 | 1 | 5 | 1 | 12.48 | 4.4 | 5.7 | 187 | 177 | 3.7 | 30.8 | 19.2 | 163.9 | 3.9 |
| 165 | 1 | 5 | 1 | 13.04 | 4.2 | 6.9 | 177 | 216 | 3.4 | 22.5 | 22.2 | 129.3 | 4.3 |
| 166 | 1 | 5 | 1 | 12.70 | 4.2 | 6.2 | 183 | 223 | 3.9 | 29.9 | 18.6 | 176.3 | 3.8 |
| 167 | 1 | 5 | 1 | 13.49 | 4.6 | 6.9 | 199 | | | | | | |
| 168 | 1 | 5 | 1 | 14.04 | 4.8 | 7.6 | 190 | | | | | | |
| 169 | 1 | 5 | 1 | 12.92 | 4.3 | 6.8 | 182 | 144 | 3.3 | 23.2 | 21.5 | 130.8 | 4.3 |
| 170 | 2 | 5 | 1 | 13.33 | 4.3 | 6.3 | 193 | | | | | | |
| 171 | 0 | 5 | 2 | 12.54 | 3.9 | 5.4 | 187 | | | | | | |
| 172 | 0 | 5 | 2 | 12.96 | 4.2 | 6.1 | 194 | | | | | | |
| 173 | 0 | 5 | 2 | 12.76 | 3.9 | 5.6 | 183 | 135 | 4.0 | 26.0 | 21.3 | 170.8 | 4.0 |
| 174 | 0 | 5 | 2 | 13.07 | 4.0 | 5.7 | 184 | | | | | | |
| 175 | 0 | 5 | 2 | 12.90 | 3.9 | 5.1 | 181 | 157 | 3.6 | 22.6 | 21.8 | 140.4 | 4.2 |
| 176 | 0 | 5 | 2 | 13.71 | 4.4 | 6.1 | 202 | 199 | 4.0 | 27.5 | 17.9 | 194.9 | 3.7 |
| 177 | 0 | 5 | 2 | 12.84 | 4.1 | 5.2 | 195 | 148 | 3.9 | 23.4 | 21.9 | 163.0 | 4.0 |
| 178 | 1 | 5 | 2 | 13.25 | 4.4 | 6.8 | 195 | 124 | 4.1 | 29.3 | 21.1 | 171.3 | 4.1 |
| 179 | 1 | 5 | 2 | 12.79 | 4.3 | 6.0 | 186 | 103 | 4.0 | 25.0 | 21.3 | 164.9 | 4.2 |
| 180 | 1 | 5 | 2 | 12.94 | 4.4 | 6.8 | 196 | | | | | | |
| 181 | 0 | 5 | 3 | 13.11 | 4.1 | 5.2 | 190 | | | | | | |
| 182 | 0 | 5 | 3 | 13.22 | 4.1 | 5.7 | 191 | 159 | 4.2 | 30.9 | 19.2 | 194.3 | 3.9 |
| 183 | 1 | 5 | 3 | 12.78 | 4.1 | 6.1 | 182 | 189 | 3.6 | 31.2 | 20.1 | 157.9 | 3.8 |
| 184 | 1 | 5 | 3 | 12.76 | 4.1 | 6.0 | 178 | 119 | 4.2 | 31.2 | 21.5 | 179.9 | 4.3 |

| m | w | S | D | fem | fil | res | tth | #c | ppc | pl | pr | cl | f |
|-----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 185 | 1 | 5 | 3 | 13.21 | 4.5 | 6.0 | 186 | 63 | 3.8 | 33.2 | 18.5 | 175.0 | 4.0 |
| 186 | 1 | 5 | 3 | 12.36 | 4.1 | 5.6 | 190 | | | | | | |
| 187 | 1 | 5 | 3 | 12.24 | 3.9 | 5.4 | 182 | | | | | | |
| 188 | 1 | 5 | 3 | 12.54 | 4.3 | 5.3 | 183 | | | | | | |
| 189 | 1 | 5 | 3 | 12.87 | 4.2 | 6.1 | 180 | | | | | | |
| 190 | 2 | 5 | 3 | 13.51 | 4.1 | 5.6 | 180 | | | | | | |
| 191 | 0 | 5 | 4 | 11.97 | 4.2 | 4.4 | 196 | 145 | 3.8 | 25.5 | 23.4 | 142.2 | 4.0 |
| 192 | 0 | 5 | 4 | 12.96 | 4.5 | 5.7 | 196 | 148 | 3.4 | 22.4 | 21.8 | 132.9 | 4.1 |
| 193 | 0 | 5 | 4 | 13.68 | 4.3 | 5.8 | 190 | | | | | | |
| 194 | 0 | 5 | 4 | 13.87 | 4.7 | 5.9 | 194 | 158 | 3.6 | 22.8 | 22.7 | 135.7 | 3.8 |
| 195 | 0 | 5 | 4 | 13.75 | 4.5 | 5.3 | 197 | 148 | 3.7 | 21.2 | 23.6 | 139.4 | 4.1 |
| 196 | 0 | 5 | 4 | 11.75 | 3.8 | 4.3 | 187 | 488 | 3.5 | 21.8 | 20.8 | 142.2 | 3.9 |
| 197 | 1 | 5 | 4 | 12.18 | 4.1 | 5.4 | 174 | | | | | | |
| 198 | 1 | 5 | 4 | 12.92 | 4.4 | 6.4 | 183 | 182 | 3.7 | 32.2 | 19.5 | 162.9 | 3.7 |
| 199 | 1 | 5 | 4 | 13.94 | 5.0 | 7.0 | 210 | 168 | 3.7 | 24.9 | 22.6 | 135.0 | 4.0 |
| 200 | 2 | 5 | 4 | 13.72 | 4.4 | 6.4 | 197 | | | | | | |
| 201 | 1 | 6 | 1 | 12.69 | 4.1 | 6.3 | 191 | | | | | | |
| 202 | 1 | 6 | 1 | 13.07 | 4.4 | 6.7 | 191 | 125 | 3.8 | 25.2 | 21.9 | 152.5 | 4.1 |
| 203 | 1 | 6 | 1 | 12.57 | 4.1 | 5.7 | 189 | 110 | 3.8 | 25.9 | 18.2 | 176.1 | 3.9 |
| 204 | 1 | 6 | 1 | 12.38 | 4.0 | 5.5 | 180 | 139 | 3.9 | 26.8 | 19.4 | 169.7 | 3.9 |
| 205 | 1 | 6 | 1 | 12.90 | 4.2 | 6.0 | 189 | 156 | 3.9 | 26.5 | 20.0 | 175.7 | 3.8 |
| 206 | 1 | 6 | 1 | 13.60 | 4.4 | 6.2 | 196 | 152 | 3.9 | 26.6 | 20.9 | 170.3 | 4.0 |
| 207 | 1 | 6 | 1 | 13.29 | 4.1 | 5.4 | 187 | | | | | | |
| 208 | 1 | 6 | 1 | 14.14 | 4.7 | 7.6 | 206 | 150 | 3.6 | 29.2 | 21.0 | 151.8 | 3.9 |
| 209 | 1 | 6 | 1 | 12.84 | 4.2 | 6.2 | 191 | 103 | 4.0 | 20.0 | 23.4 | 152.8 | 3.9 |
| 210 | 1 | 6 | 1 | 12.77 | 4.2 | 6.0 | 194 | 146 | 3.7 | 27.9 | 19.0 | 168.0 | 3.8 |
| 211 | 0 | 6 | 2 | 12.21 | 4.1 | 5.6 | 194 | 128 | 3.8 | 25.5 | 19.8 | 175.2 | 4.1 |
| 212 | 1 | 6 | 2 | 13.75 | 4.5 | 7.1 | 198 | 155 | 3.6 | 27.1 | 20.9 | 149.5 | 4.0 |
| 213 | 1 | 6 | 2 | 13.01 | 4.5 | 6.5 | 190 | | | | | | |
| 214 | 1 | 6 | 2 | 14.53 | 4.4 | 6.5 | 196 | 115 | 3.9 | 31.2 | 17.3 | 193.7 | 4.1 |
| 215 | 1 | 6 | 2 | 14.11 | 4.5 | 7.0 | 190 | | | | | | |
| 216 | 1 | 6 | 2 | 13.85 | 4.4 | 7.0 | 178 | 124 | 3.6 | 24.0 | 21.7 | 145.7 | 3.9 |
| 217 | 1 | 6 | 2 | 13.34 | 4.5 | 6.8 | 179 | 90 | 3.7 | 22.9 | 19.9 | 162.3 | 3.9 |
| 218 | 1 | 6 | 2 | 14.22 | 4.4 | 6.7 | 187 | | | | | | |
| 219 | 1 | 6 | 2 | 13.92 | 4.4 | 7.0 | 190 | | | | | | |
| 220 | 1 | 6 | 2 | 13.37 | 4.2 | 6.1 | 182 | 136 | 3.3 | 24.9 | 21.3 | 132.0 | 4.1 |
| 221 | 0 | 6 | 3 | 13.12 | 4.1 | 5.9 | 186 | | | | | | |
| 222 | 0 | 6 | 3 | 12.94 | 3.9 | 5.5 | 183 | | | | | | |
| 223 | 0 | 6 | 3 | 13.38 | 4.1 | 5.7 | 193 | 129 | 3.7 | 21.2 | 21.5 | 147.1 | 4.0 |
| 224 | 0 | 6 | 3 | 12.31 | 3.8 | 5.9 | 189 | 304 | 3.9 | 24.2 | 20.9 | 162.2 | 3.7 |
| 225 | 1 | 6 | 3 | 13.46 | 4.0 | 6.9 | 183 | | | | | | |
| 226 | 1 | 6 | 3 | 12.47 | 4.1 | 5.9 | 188 | | | | | | |
| 227 | 1 | 6 | 3 | 12.16 | 4.0 | 5.5 | 187 | | | | | | |
| 228 | 1 | 6 | 3 | 13.41 | 4.3 | 6.3 | 185 | 225 | 3.5 | 18.1 | 21.4 | 136.2 | 3.8 |
| 229 | 1 | 6 | 3 | 11.75 | 4.0 | 5.7 | 185 | | | | | | |
| 230 | 2 | 6 | 3 | 11.92 | 4.0 | 6.0 | 185 | | | | | | |

| m | w | S | D | fem | fil | res | tth | #c | ppc | pl | pr | cl | f |
|-----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 231 | 0 | 6 | 4 | 12.32 | 4.3 | 5.9 | 210 | | | | | | |
| 232 | 0 | 6 | 4 | 13.15 | 3.9 | 5.0 | 188 | 134 | 3.6 | 25.2 | 18.8 | 159.3 | 3.8 |
| 233 | 0 | 6 | 4 | 13.25 | 4.0 | 5.5 | 190 | | | | | | |
| 234 | 0 | 6 | 4 | 11.81 | 3.6 | 4.5 | 182 | | | | | | |
| 235 | 1 | 6 | 4 | 11.97 | 4.2 | 6.0 | 206 | | | | | | |
| 236 | 1 | 6 | 4 | 12.06 | 4.3 | 5.7 | 199 | 112 | 3.6 | 26.4 | 20.9 | 144.0 | 3.8 |
| 237 | 1 | 6 | 4 | 12.48 | 4.4 | 6.2 | 196 | | | | | | |
| 238 | 1 | 6 | 4 | 12.89 | 4.4 | 5.8 | 201 | 160 | 3.5 | 24.7 | 21.5 | 137.8 | 4.0 |
| 239 | 1 | 6 | 4 | 13.80 | 4.7 | 6.4 | 199 | 77 | 3.8 | 29.9 | 18.5 | 166.7 | |
| 240 | 1 | 6 | 4 | 12.48 | 4.2 | 6.0 | 199 | | | | | | |
| 241 | 0 | 7 | 1 | 12.33 | 4.0 | 5.3 | 192 | | | | | | |
| 242 | 0 | 7 | 1 | 11.14 | 3.8 | 5.1 | 186 | 199 | 4.2 | 22.4 | 21.8 | 164.9 | 4.5 |
| 243 | 0 | 7 | 1 | 12.31 | 4.0 | 4.9 | 194 | | | | | | |
| 244 | 0 | 7 | 1 | 11.34 | 3.6 | 4.4 | 181 | 208 | 4.2 | 27.2 | 20.7 | 177.6 | 3.8 |
| 245 | 1 | 7 | 1 | 12.12 | 4.2 | 6.2 | 195 | 172 | 3.7 | 28.8 | 18.4 | 166.9 | 4.0 |
| 246 | 1 | 7 | 1 | 12.62 | 4.2 | 5.6 | 182 | 173 | 4.2 | 28.6 | 22.0 | 171.2 | |
| 247 | 1 | 7 | 1 | 11.65 | 4.1 | 5.5 | 194 | | | | | | |
| 248 | 1 | 7 | 1 | 12.41 | 4.3 | 5.9 | 194 | 109 | 3.6 | 22.2 | 22.9 | 134.2 | 4.3 |
| 249 | 1 | 7 | 1 | 11.82 | 4.2 | 5.2 | 182 | | | | | | |
| 250 | 2 | 7 | 1 | 12.45 | 4.1 | 5.2 | 194 | 212 | 3.6 | 25.4 | 21.4 | 149.5 | 3.7 |
| 251 | 0 | 7 | 2 | 12.62 | 3.9 | 5.7 | 205 | | | | | | |
| 252 | 1 | 7 | 2 | 13.37 | 4.1 | 5.8 | 193 | 354 | 4.1 | 25.6 | 19.4 | 169.7 | 4.0 |
| 253 | 1 | 7 | 2 | 12.82 | 4.4 | 5.5 | 199 | | | | | | |
| 254 | 1 | 7 | 2 | 13.25 | 4.5 | 6.1 | 199 | 133 | 3.4 | 23.5 | 26.0 | 115.8 | 4.0 |
| 255 | 1 | 7 | 2 | 12.69 | 4.2 | 6.0 | 192 | 130 | 3.6 | 22.7 | 20.7 | 147.7 | 3.9 |
| 256 | 1 | 7 | 2 | 12.27 | 3.9 | 5.4 | 171 | 145 | 3.7 | 24.7 | 20.9 | 152.4 | 4.1 |
| 257 | 1 | 7 | 2 | 13.42 | 4.6 | 7.0 | 198 | | | | | | |
| 258 | 1 | 7 | 2 | 12.79 | 4.1 | 5.7 | 190 | 104 | 3.3 | 19.8 | 23.6 | 117.1 | 4.3 |
| 259 | 1 | 7 | 2 | 12.91 | 4.1 | 6.1 | 188 | | | | | | |
| 260 | 1 | 7 | 2 | 12.80 | 3.9 | 5.9 | 186 | | | | | | |
| 261 | 0 | 7 | 3 | 12.55 | 3.9 | 4.8 | 201 | 125 | 3.6 | 20.0 | 24.6 | 125.9 | 4.1 |
| 262 | 0 | 7 | 3 | 12.15 | 4.0 | 5.0 | 190 | 112 | 3.9 | 25.1 | 21.9 | 160.9 | 3.9 |
| 263 | 0 | 7 | 3 | 13.30 | 4.2 | 6.7 | 201 | 187 | 3.5 | 28.6 | 17.5 | 169.8 | 3.7 |
| 264 | 0 | 7 | 3 | 13.30 | 4.2 | 6.3 | 201 | | | | | | |
| 265 | 1 | 7 | 3 | 12.17 | 3.8 | 5.5 | 183 | | | | | | |
| 266 | 1 | 7 | 3 | 12.12 | 4.0 | 6.3 | 190 | | | | | | |
| 267 | 1 | 7 | 3 | 12.30 | 4.2 | 5.9 | 189 | 91 | 4.2 | 22.1 | 23.2 | 153.5 | 3.8 |
| 268 | 1 | 7 | 3 | 13.06 | 4.6 | 6.7 | 195 | | | | | | |
| 269 | 1 | 7 | 3 | 12.87 | 4.3 | 6.4 | 199 | | | | | | |
| 270 | 2 | 7 | 3 | 13.76 | 4.2 | 6.4 | 191 | 76 | 3.6 | 24.0 | 23.5 | 139.1 | 3.8 |
| 271 | 0 | 7 | 4 | 13.20 | 4.0 | 6.0 | 178 | | | | | | |
| 272 | 0 | 7 | 4 | 12.30 | 4.0 | 6.1 | 192 | | | | | | |
| 273 | 0 | 7 | 4 | 11.76 | 3.8 | 5.3 | 179 | 147 | 3.4 | 21.7 | 23.2 | 127.9 | 3.9 |
| 274 | 0 | 7 | 4 | 13.03 | 4.3 | 6.1 | 205 | 99 | 3.3 | 23.7 | 23.1 | 120.8 | 3.8 |
| 275 | 0 | 7 | 4 | 13.34 | 4.3 | 6.4 | 204 | | | | | | |

| m | w | S | D | fem | fil | res | th | #c | ppc | pl | pr | cl | f |
|-----|---|---|---|-------|-----|-----|-----|-----|-----|------|------|-------|-----|
| 276 | 1 | 7 | 4 | 11.66 | 4.2 | 6.2 | 199 | 84 | 4.1 | 23.8 | 22.9 | 158.3 | 4.1 |
| 277 | 1 | 7 | 4 | 12.61 | 4.0 | 6.0 | 197 | | | | | | |
| 278 | 1 | 7 | 4 | 12.97 | 4.5 | 7.2 | 194 | 122 | 3.5 | 21.0 | 25.3 | 122.9 | 4.2 |
| 279 | 1 | 7 | 4 | 12.51 | 4.2 | 6.6 | 194 | | | | | | |
| 280 | 1 | 7 | 4 | 12.32 | 4.1 | 6.4 | 184 | | | | | | |
| 281 | 0 | 8 | 1 | 13.02 | 4.2 | 5.5 | 196 | 147 | 4.0 | 26.8 | 20.3 | 172.0 | 3.9 |
| 282 | 0 | 8 | 1 | 14.21 | 4.5 | 5.5 | 199 | 239 | 3.9 | 24.0 | 18.9 | 176.4 | 3.9 |
| 283 | 0 | 8 | 1 | 13.39 | 4.3 | 6.3 | 189 | 152 | 4.0 | 25.0 | 18.9 | 177.5 | 3.9 |
| 284 | 0 | 8 | 1 | 13.43 | 4.1 | 5.9 | 194 | 125 | 4.0 | 26.5 | 19.4 | 175.7 | 3.7 |
| 285 | 0 | 8 | 1 | 13.95 | 4.2 | 5.7 | 189 | | | | | | |
| 286 | 1 | 8 | 1 | 11.98 | 3.8 | 4.7 | 182 | 86 | 4.3 | 25.5 | 22.9 | 167.9 | 3.8 |
| 287 | 1 | 8 | 1 | 12.95 | 4.2 | 7.0 | 185 | | | | | | |
| 288 | 1 | 8 | 1 | 13.19 | 4.4 | 5.6 | 180 | 182 | 3.9 | 24.3 | 23.3 | 147.8 | 4.2 |
| 289 | 1 | 8 | 1 | 13.33 | 4.2 | 5.9 | 200 | 232 | 4.0 | 23.2 | 21.2 | 161.1 | 4.0 |
| 290 | 1 | 8 | 1 | 13.11 | 4.4 | 5.7 | 188 | | | | | | |
| 291 | 0 | 8 | 2 | 12.51 | 3.9 | 4.7 | 200 | | | | | | |
| 292 | 0 | 8 | 2 | 12.29 | 3.9 | 4.8 | 186 | 119 | 3.4 | 22.0 | 22.8 | 123.9 | 4.1 |
| 293 | 0 | 8 | 2 | 12.05 | 4.1 | 5.5 | 207 | 200 | 3.9 | 26.4 | 19.7 | 171.4 | 4.1 |
| 294 | 0 | 8 | 2 | 12.81 | 3.7 | 4.7 | 188 | 114 | 3.6 | 21.1 | 19.6 | 153.9 | 3.8 |
| 295 | 1 | 8 | 2 | 12.74 | 4.3 | 5.5 | 189 | 146 | 3.3 | 24.7 | 21.0 | 133.5 | 4.1 |
| 296 | 1 | 8 | 2 | 13.11 | 4.1 | 5.4 | 184 | | | | | | |
| 297 | 1 | 8 | 2 | 13.05 | 4.3 | 5.8 | 180 | 127 | 3.8 | 26.6 | 18.2 | 172.1 | |
| 298 | 1 | 8 | 2 | 13.65 | 4.4 | 5.8 | 188 | 238 | 4.0 | 27.3 | 17.4 | 179.4 | 3.9 |
| 299 | 1 | 8 | 2 | 12.53 | 4.2 | 5.6 | 183 | 206 | 3.2 | 22.6 | 22.5 | 116.6 | 4.3 |
| 300 | 1 | 8 | 2 | 12.43 | 4.1 | 5.7 | 190 | 192 | 4.3 | 22.3 | 20.3 | 189.0 | 3.8 |
| 301 | 0 | 8 | 3 | 13.26 | 4.4 | 5.3 | 187 | | | | | | |
| 302 | 0 | 8 | 3 | 13.44 | 4.2 | 5.6 | 190 | | | | | | |
| 303 | 0 | 8 | 3 | 14.35 | 4.4 | 6.1 | 201 | 142 | 3.5 | 20.0 | 23.7 | 126.6 | 3.8 |
| 304 | 0 | 8 | 3 | 12.89 | 4.1 | 5.1 | 191 | | | | | | |
| 305 | 0 | 8 | 3 | 12.73 | 4.2 | 5.7 | 203 | 120 | 3.6 | 19.7 | 22.9 | 133.1 | 4.0 |
| 306 | 0 | 8 | 3 | 13.28 | 4.1 | 5.2 | 185 | | | | | | |
| 307 | 0 | 8 | 3 | 12.85 | 4.0 | 3.6 | 199 | 265 | 3.5 | 23.3 | 21.9 | 138.1 | 3.8 |
| 308 | 0 | 8 | 3 | 12.86 | 4.2 | 5.5 | 196 | 73 | 3.9 | 24.6 | 20.6 | 165.7 | 4.0 |
| 309 | 0 | 8 | 3 | 12.55 | 4.0 | 4.3 | 189 | 127 | 4.0 | 20.9 | 22.9 | 146.0 | 4.2 |
| 310 | 1 | 8 | 3 | 13.90 | 4.5 | 5.9 | 188 | 159 | 3.6 | 27.5 | 18.4 | 165.4 | 3.9 |
| 311 | 0 | 8 | 4 | 12.91 | 4.1 | 5.4 | 178 | 105 | 3.6 | 23.7 | 22.9 | 135.5 | 4.0 |
| 312 | 0 | 8 | 4 | 12.19 | 4.0 | 5.4 | 184 | 116 | 4.0 | 21.0 | 25.3 | 149.0 | 3.9 |
| 313 | 0 | 8 | 4 | 12.82 | 3.9 | 5.1 | 193 | | | | | | |
| 314 | 0 | 8 | 4 | 11.28 | 3.7 | 4.6 | 182 | | | | | | |
| 315 | 0 | 8 | 4 | 11.33 | 3.7 | 4.3 | 175 | 143 | 3.7 | 23.8 | 21.7 | 142.8 | 4.2 |
| 316 | 1 | 8 | 4 | 12.12 | 4.1 | 5.6 | 189 | 134 | 3.6 | 28.4 | 20.9 | 141.2 | 4.0 |
| 317 | 1 | 8 | 4 | 12.51 | 4.0 | 5.4 | 197 | 106 | 3.6 | 24.2 | 21.8 | 140.9 | 3.9 |
| 318 | 1 | 8 | 4 | 13.06 | 4.3 | 6.4 | 208 | | | | | | |
| 319 | 1 | 8 | 4 | 12.95 | 4.2 | 6.4 | 186 | 184 | 3.3 | 26.4 | 21.4 | 130.1 | 4.0 |
| 320 | 2 | 8 | 4 | 13.59 | 4.0 | 6.1 | 183 | 50 | 3.8 | 25.2 | 21.3 | 154.6 | 3.8 |