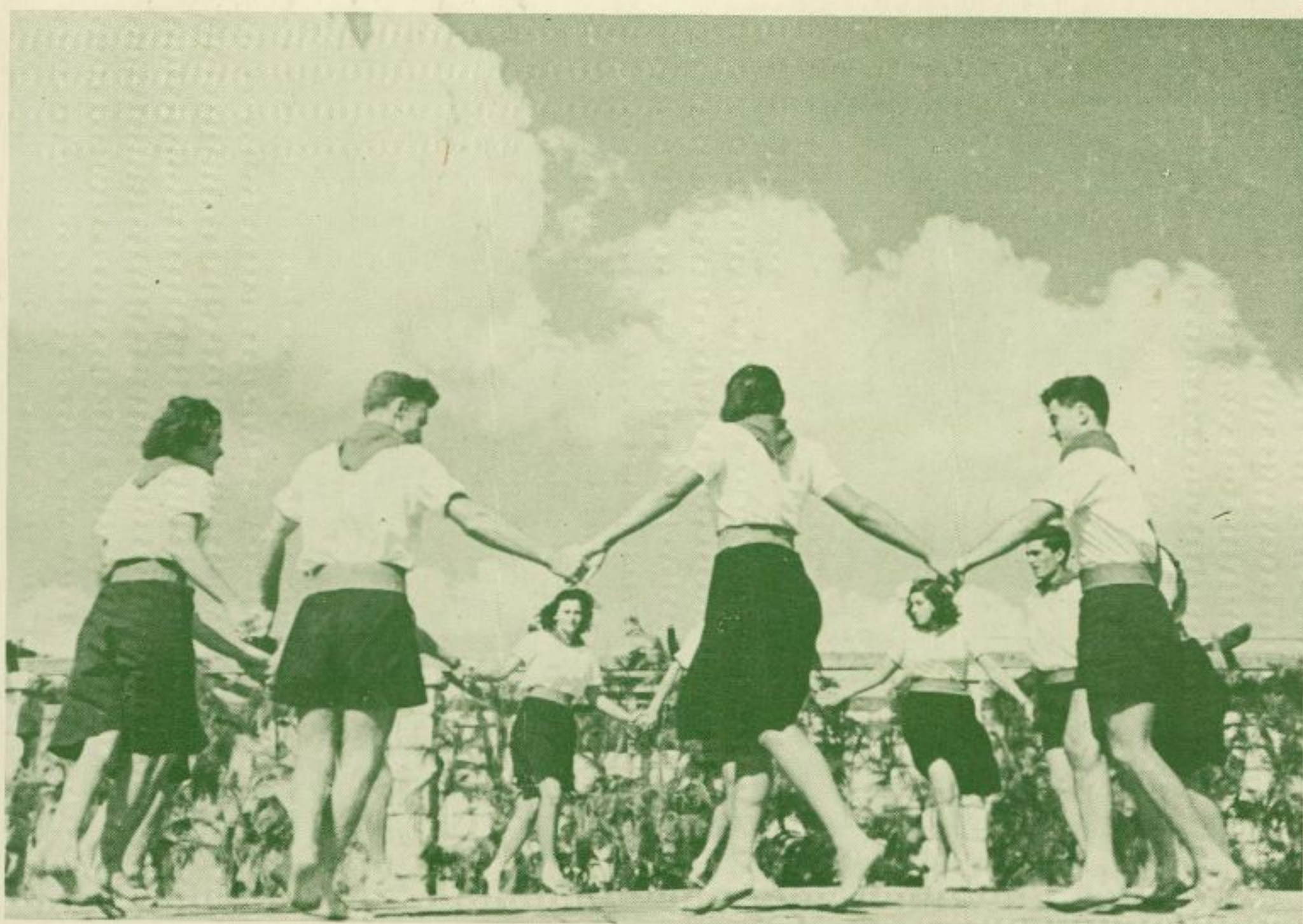Dalia Cohen * Ruth Katz

THE ISRAELI FOLK SONG: A METHODOLOGICAL EXAMPLE OF COMPUTER ANALYSIS OF MONOPHONIC MUSIC

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VI

YUVAL MONOGRAPH SERIES
VI

Dalia Cohen   *   Ruth Katz

THE ISRAELI FOLK SONG:
A METHODOLOGICAL EXAMPLE
OF COMPUTER ANALYSIS
OF MONOPHONIC MUSIC

C O N T E N T S

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AIMS OF THE STUDY AND THE SELECTED MATERIAL

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III
NOTES, REFERENCES, APPENDICES, ETC.

I

AIMS OF THE STUDY AND THE SELECTED MATERIAL

*

INTRODUCTION

This study has a two-fold purpose: the presentation of one kind of examination of a specific musical repertoire in the field of the so-called Israeli folk-song, and the development of a method for examining and defining the style of a large monodic repertoire with the aid of the computer.

The computer has of course been increasingly used in recent years in the humanities. In the field of music experiments utilizing the computer have been carried out in the definition of style, but the computer has not yet been accepted as ordinary equipment in musical research. Each experiment of this kind is by way of exception, and methods that would be applicable to the study of all kinds of music have not yet been established. Nevertheless, several methods have been developed that are particularly suited to certain types of musical repertoire[1].

In our first computer-aided endeavor we chose to concentrate on the stylistic problems of monodic music only. Diverse repertoires, like Arab folk music, for example, or medieval monodic music, both secular and sacred, may be defined from various points of view. Although the music of the Middle Ages has to a large extent been examined, there still remain certain questions that the computer may be able to answer, e.g. to what extent was the mode defined in the Gregorian chant, by way of motifs? Or, what is the importance

of the order of notes (as far as time sequence is concerned)? Or,
is the arrangement of notes or of motifs *in time* conditioned by
certain national predilections, as in the Italian *laude*, the
Spanish *cantigas*, the music of the French troubadours and trouvères,
etc...?[2]

In our study we shall attempt to demonstrate a method by apply-
ing it to Israeli folk songs - a case where stylistic examination
accompanied the songs from their inception.

Most musicians in Israel - musicologists, composers, teachers
and amateurs - have dealt, in one way or another, with the Israeli
song, and most of the musical material that served as the basis
for their work was included in our study[3].

Since we wished to be as objective as possible in our evaluation
of the musical examples, we had to break them down into a maximum
number of parameters. Upon examination, these enabled us to arrive
at a common denominator, which thus served as the basis for the
comparison of tunes. Without going into details, - which will be
presented in the course of the study, - we may here point out that
even a short and comprehensible tune such as "Frère Jacques" can
answer hundreds of questions when its distinctiveness is being
assessed.

THE EVOLUTION OF THE ISRAELI FOLK-SONG - SOME REMARKS

The development of Israeli or Hebrew folk-song gives rise to
some interesting questions related to extra-musical factors. The
special conditions under which the Israeli song was created and
consolidated emphasize problems connected with culture contact as
well as problems dealing with the relationship between folk-song
and art-song. These subjects deserve separate discussion. At

this point it is sufficient to mention that the Hebrew song is, in no small measure, the creation of composers who consciously or unconsciously sought a means of tonal organization that would reflect both the people's attachment to the land and the ingathering of the exiles.

Israeli folk-song is unique in that it is still possible to trace its origins and composers, a phenomenon contradicting the definition generally accepted by scholars, which declares that folklore and folk music are handed down from generation to generation, adopted by the masses as an integral part of their folk tradition, neither the composer nor the date of composition being known in most cases. In the course of several decades, Israeli folk-song incorporated songs of various non-Jewish traditions, particularly German and Russian. The struggle against such "foreign imports" was carried on enthusiastically, and many Jewish musicians saw their life's work in collecting, researching, encouraging and popularizing Jewish music among their people. One of these, the composer Joachim Stutschewsky, wrote: "Is it possible that this song (foreign) can express all our sentiments and give content and taste to our lives, our pains and our joys? ... We cannot be indifferent to the subject of what our children sing... Have you heard the songs sung by our youngsters when they march in the streets? I myself am shocked to my very being..." (Stutschewski 1945:65-66).

In Israel songs are closely connected with two main kinds of cultural activities: one is the festival, and the other is folk dancing. Much thought and labour has been invested in the moulding of these two activities. Festivals hold an important place in the lives of those who returned to the land of the Patriarchs - the gateway to a new life. They also serve as an educational factor in the elevation and unification of society. The festival,

with its traditional forms, and newer aspects reflecting the new
reality, creates a link between the generations. Ancient customs
from the past have been revived. The musical activities surround-
ing the festivals still continue to resemble the older religious
ceremonies to a certain extent. Today, for example, in various
versions of the Passover festival a symbolical combination of the
ideas of freedom and spring can be found. In the diaspora freedom
was the main idea expressed in the Passover ceremony, whereas in
the Biblical period the emphasis was on the festival of the sheaves
of corn, connected with a season of the year, spring. This holi-
day, like many others, is particularly popular in the *kibbutzim*,
the Israeli communes. It is worth mentioning that the concept of
festival, which greatly enriched the repertoire of Israeli song,
includes not only the traditional festivals but also the ceremonies
and gatherings that accompany various contemporary events. During
the past twenty-five years, dozens of booklets containing songs
for holidays and other events were published, and were also used
as educational material in the schools.

The second activity that spurred musical creativity is the folk
dance, which in part was combined with the festivals. Gurit
Kadman, one of the creators of the Israeli dance, remarks on the
meaning of these dances and their connection with music: "The
dances are 'artificial' as the State of Israel is artificial, as
the fate of the people of Israel and its history is in itself
abnormal..." (1969:67). "It is a fact that just those dances that
are successful were created by young musicians who were close to
dancing circles for years, as accompanists or advisers." (1969:
60). "Almost all of the creators derive their inspiration from
songs, most of which are also new creations. Although the
beginnings of composition in the field of folk music precede the
creation of dances by several tens of years, the most fruitful

years for the composition of dance and song alike were from 1944
onwards. And, as in the case of the dances, most of the composers
of folk songs were members of *kibbutzim*, some of whom were shep-
herds who composed their songs in the fields, with the aid of the
flute." (1969:71).

It seems to us, that apart from specific interest involved in
furthering the understanding of the Israeli folk song, the genre
serves as a good example for our purpose. Scholars who have dealt
with the Israeli song, have stressed, without exception, the
uniqueness of the Hebrew song, although their analyses with regard
to the songs themselves may have differed. Some spoke of "anony-
mous" scales (Ravina, 1968); some saw the crystallization of a
maqām (Bayer, 1968); others, again, working back from the known
material, have attempted to reconstitute the ancient sources from
which the Hebrew and other songs are derived (Shmueli, 1968). Yet
all agree that a corpus that can be termed "the Hebrew song" does
in fact exist. We have tried to determine the character and
uniqueness of this corpus, particularly in its melodic aspects, by
a method of examination that we have evolved for the purpose.

OUR CHOICE OF REPERTOIRE

The material selected for examination has appeared in collec-
tions published by various Israeli agencies, such as the Ministry
of Education and Culture, the Centre for Culture and Information,
as well as by educators and composers whose aim was the promotion
of the Hebrew song. Our sampling also includes many songs
selected by various researchers. The collections to which we
refer do not include "hit tunes". Without delving into the
difference between a popular song and a folk song - a distinction

which is not always clear and that takes on various shades of
meaning in different musical cultures - a line of demarcation
between the two cannot be avoided, since most popular songs are
short-lived, and closely connected with international fashions.
Similarly, the material we examined did not include the purely
ethnic songs that undoubtedly served as a source and inspiration
for both the folk and the artistic song. It would be interesting
to examine the ethnic sources as well, and to see to what extent
they fit into the local setting, if they indeed fit in at all.

A somewhat different method would be required for the examina-
tion of ethnic-group songs in Israel, and many songs of the Middle
East region. Although the Israeli song has a great deal in common
with the songs of bordering areas, two important distinguishing
characteristics can be identified: 1) the intonation is fixed,
inasmuch as any singing can be fixed, and tempered; and 2) improvi-
sation in performance has no part in moulding the song. An
examination of other songs of the region, including those from
oriental Jewish communities, has to take the varying renditions of
actual performances into account. Where actual performance is an
integral part of the composition, an examination disregarding this
factor would be meaningless[4]. In the amorphous corpus that is
called the Hebrew song, we deliberately concentrated upon the
melodies which were confined to modal frameworks. The term "mode"
is used here in its widest sense, i.e. melody type, and may also
include *shtaiger* (a Jewish modal framework) or *maqām*. For the
sake of simplicity we chose the most common musical term, i.e. one
not limited to any particular time or place.

We realize that one cannot deal with the Hebrew song by means
of rigid concepts, such as that of scale alone. However, while
there can be no doubt that melodic patterns play an important role
in the moulding of the Hebrew song, we found it necessary, first

and foremost, to organize all our material according to scale
groupings, which, in our opinion, have not been accorded their due
importance because of the concentration upon melodic patterns and
the desire to avoid Western thinking. For example, the patterns
of the *zarka*[5] in Shmueli's research (1968:63-68) are not mentioned
as characteristic of a particular mode, though they are, in fact,
found only in songs in the Dorian and Aeolian modes. On the other
hand, these patterns are not found in any of the songs of the
maqām haqômemiût ['stand fast'] of Bayer (1968), or even in the
Mixolydian. Obviously, the concept of scale cannot be regarded
here - or in most other cases, for that matter - only from the
point of view of the combination of identical tetrachords. The
scale may be composed of different groupings of tetrachords, penta-
chords or trichords, conjunct or disjunct or both, as Smoira-Cohen
(1963:57) has already pointed out.

It is true that there are quite a number of Hebrew songs for
which scale cannot be readily determined, because of chromatic
alterations in the partial groupings of the song. For example, in
Amitai Ne'eman's *Sîr han-no[c]ar* ("The Song of Youth"), because of
its chromaticism, all the "minor" scales may be interpreted as
either Phrygian, Aeolian or Dorian (Ex.).

Another example is the song *Dôdî zah we-adôm* ("My beloved is
fair and ruddy") by Emanuel Amiran (Ex. II) where the first part
comprises a major tetrachord and the continuation is either
Mixolydian or Dorian. The majority of Hebrew songs, however,
can be easily classified as far as scales are concerned.
Undoubtedly, the largest group is in the minor key and includes
many tunes of varying character, from which we have chosen
only those belonging to the Dorian mode, including tunes described
by Ravina as "anonymous" (1968: 71-78), i.e. lacking the sixth
degree, which makes it impossible to describe them as Dorian

Musical Example No. I

Šîr han-no^C ar, composed in different scales of the minor modes:

>   Bars 1-6 - "Anonymous";
>
>   Bars 7-8 - Phrygian;
>
>   Bars 9-12 - Dorian;
>
>   Bars 14-16 - Aeolian.

Šîr han-nô^C ar (A. Ne'eman)   שיר הנער (א. נאמן)

(In fact, the above analysis is somewhat artificial and reflects
a Western way of thinking. An Oriental approach to the song would
treat the chromatic alterations as characteristic of certain
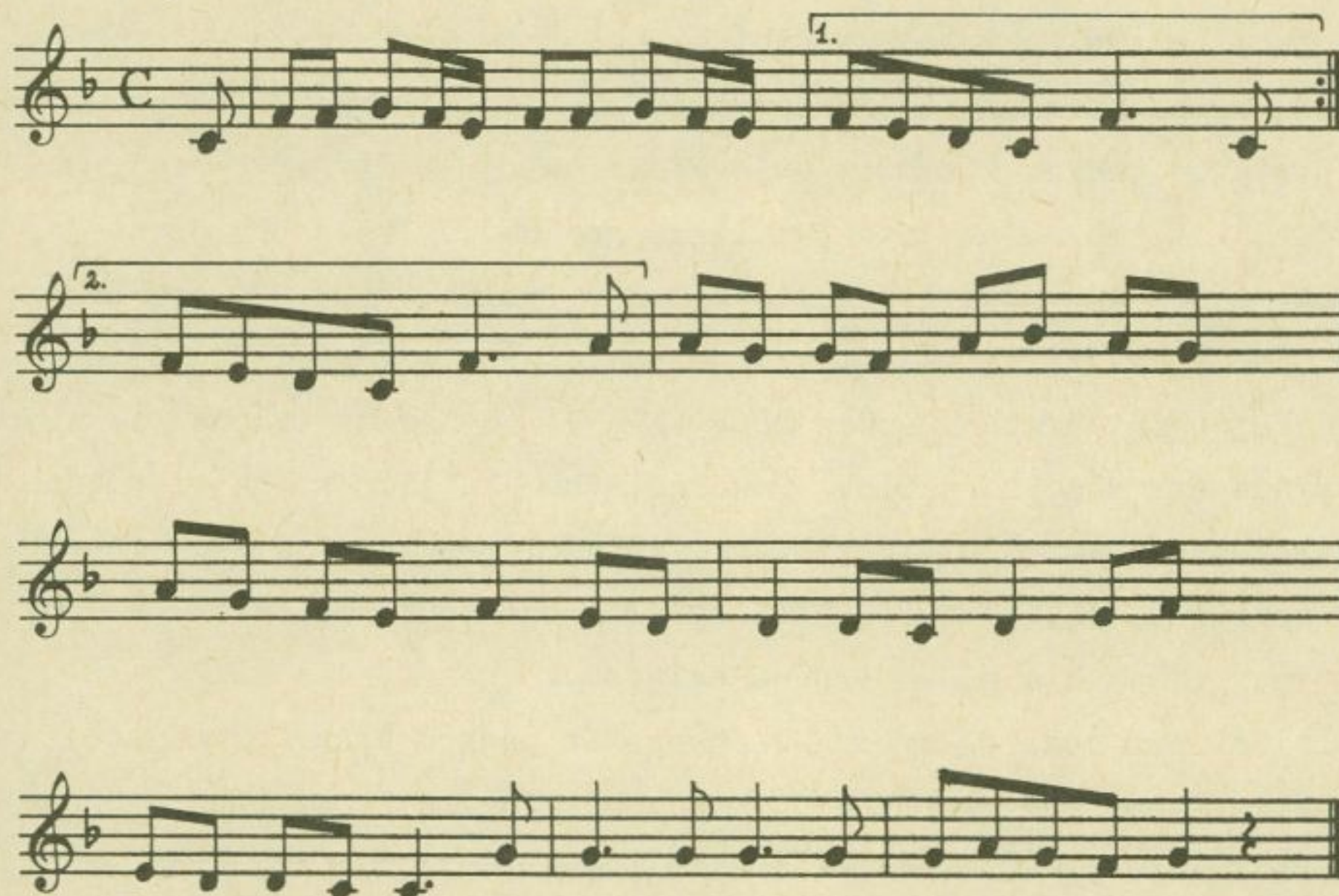degrees of the scale.)

Musical Example No. II

The song *Dôdî zah we-adôm* clearly begins in the major mode but its continuation is not clear. It may be Dorian or Aeolian. The song clearly ends in the Mixolydian mode.

Dôdî zah we-adôm (E. Amiran)   דודי צח ואדום (ע. עמירן)

or Aeolian. There are many Israeli songs of this type. Tunes in
the Mixolydian mode were chosen because they are also quite
popular and closely resemble a "melody type". In contrast to the
Dorian and Mixolydian, we included a group of songs in the scale
called *Hassidic,Ahava-Rabah* or *hedjaz*[6]. Most of the songs in this
latter group relate to two traditions: the Jewish Eastern European[6a]
and the local Arabic. These songs are accepted as "Israeli"
despite the reservations of the "purists", and their important
place in the Israeli repertoire cannot be ignored.

The classification could have been made either following Orgad's
division, which attempts to reveal stylistic differences by
dividing the songs into two large groups entitled "European-
harmonic" and "Eastern-melodic" (n.d.: 11-12; 52-54); or Smoira-
Cohen's division, which is based on historical periods in the
development of the Hebrew song (1963). Other divisions of various
kinds are also possible. However, the division which we ultimate-
ly chose enabled us to examine, in addition to stylistic charac-
teristics, the place of the scale in the moulding of the melody
type, if such a place indeed exists.

For our control group, we chose at random a number of additional
songs from each group, and found that they did not basically alter
our findings. The repertoire that was subjected to close examina-
tion consisted of sixty songs popular among the Israeli public and
which in our opinion faithfully represent the Israeli repertoire.
The four groups that we chose to concentrate upon were: the *Hedjaz*,
the Dorian, the Mixolydian and the major. Confirmation that the
songs we selected do represent the typical Israeli repertoire lies
in the fact that most of them are included not only in the writ-
ings of Israeli musical researchers (see fn. 4) but are also among
the songs taught in schools and in various song books, and many
serve as folk dance music[7].

II

METHODS AND FINDINGS

The information gathered in order to define the style of the
Israeli song pertains to many subjects comprising individual
details, as well as their organization into large units. The
information obtained is based on two major methods of preparation
for computerization:

1) a numerical representation of the main notes of the tune, in
the order of their appearance;

2) a classification of the material in accordance with a prepared
questionnaire, consisting of 54 questions regarding the various
musical characteristics.

The methods of preparation enabled the assessment of the musical
parameters as well as the relationship between them and above all
the meaning of the modal framework in the Israeli folk-song.

INFORMATION REGARDING STYLE THROUGH NUMERICAL
PRESENTATION OF THE NOTES OF A MELODY

Every song was described with the aid of a row of seventy-five
numerical configurations corresponding to the notes of the tune,
in the following manner: *do* - 1; *re* - 2; etc.[8] By choosing a
fixed number of notes from each melody, it was possible to compare
them; if each of the tunes had been described by a different
number of notes, comparison would not have been possible. Although
no two tunes were equal in number of notes, it was necessary to

express each of them with the same precise instructions: the last
note always appeared at the end of the row; the first, at the
beginning; those preceding the final note, before the end; those
following the starting note, immediately after the beginning, and
so on. Short tunes are described as if they had no middle, i.e.,
the end of the tune is separated from its beginning, and the
middle of the row is represented by zeros. In this way, melodies
that are not equal in length can be compared by aligning the
endings, the beginnings, etc.

Each song was placed within a fixed framework of five phrases.
If the tune contained a greater number of phrases (a rare case), a
median phrase was removed from the description; and if there were
fewer than five, the middle of the row was represented by zeros.
Similarly, every phrase had a possibility range of five motifs,
treated according to the programme established for the phrases,
the absence of motifs being expressed by zeros. Each motif was
described by three numerical configurations. Where a motif was
composed of two notes only, it was described by three configura-
tions, the median being a zero. If the motif contained more than
three notes, the first number described the opening note, the last
number, the final note, and the middle number, the most emphasized
note situated between them. The choice of the most emphasized
median applied when there was no change in the melodic direction
of the motif. However, when there was a change of direction, the
middle number described the note upon which the melody changed
direction. When a number of changes occured in the melodic direc-
tion of the motif (very rare), the middle number described the
note on which the last change occurred. If the motif comprised
one note that was not repeated, it was described as follows: the
last configuration represents the number of the note, and the
first two configurations are zeros. To give an example of the

method: the motif *re mi fa sol la* is described by numbers 2, 4, 6
(which describe *re fa la*), while the motif *re mi fa sol fa*, by 2,
5, 4 (which describe *re sol fa*). Thus every phrase can be
described by fifteen configurations, representing five motifs,
each having three numbers, which describe the main notes[9]. The
entire song can thus be described by a row of seventy-five confi-
gurations, i.e. 15 x 5. The song *Qôl dôdî* (Ex.III) with its
numerical representation illustrates the coding system described
above. It should be recalled that this coding system, which is
able to answer only a limited but nevertheless important number of
questions, is supplemented by the questionnaire referred to pre-
viously.

From each row of configurations we can obtain, first of all,
the number of recurrences of notes in a given melody, and, by
means of simple addition, with the aid of the computer, in the
course of a few seconds, the total number of recurrences of the
notes in sets of melodies. The same information can be obtained
for notes in separate phrases, opening or concluding phrases, or
both. Some interesting facts emerged through this calculation.

Figure 1 shows the total number of recurrences of notes in all
the songs which were examined in each of the four groupings. In
this diagram we see that the note *sol* occurs most frequently,
which to a certain extent recalls the importance of *sol* in *maqāmāt*
scales, analogous to the role of *mese* in Greek music[10]. This
phenomenon justifies the choice of name for the notes in transcrib-
ing the melodies in the four chosen groupings: the major key based
on *do*, with the "dominant" *sol*; the Dorian based on *re* with *sol*
as the main central note; the Mixolydian with the "tuba" *sol*,
which frequently serves as a *finalis*; and the *hedjaz* with the
central notes *re* and *sol* functioning as the extreme notes of the
hedjaz tetrachord.

Musical Example No. III

The song *Qôl dôdî* by S. Levi, represented in a row of seventy-five numbers suited to the M.S.A. system.

a. *The song divided into phrases*

Phrase No. 1 (places 1-15)
Phrase No. 2: repetition (places 16-30)

Phrase No. 4 (places 46-60)

Phrase No. 5 (places 61-75)

b. *The song presented in numbers*

Since the song comprises four phrases only, places 31-45 reserved for phrase No. 3 will be represented by zeros in the following manner:

Phrase No. 1   212 212 000 253 402
Phrase No. 2   212 212 000 253 402
Phrase No. 3   000 000 000 000 000
Phrase No. 4   266 552 000 353 406
Phrase No. 5   266 552 000 353 402

Fig. 1 Summary of the frequency of occurrence of notes for all
melodies of the combined modal groupings.

A (Major) + B (Mixolydian) + C (Dorian) + D (Hedjaz)

do   re   mi   fa   sol   la   si   do'   re'
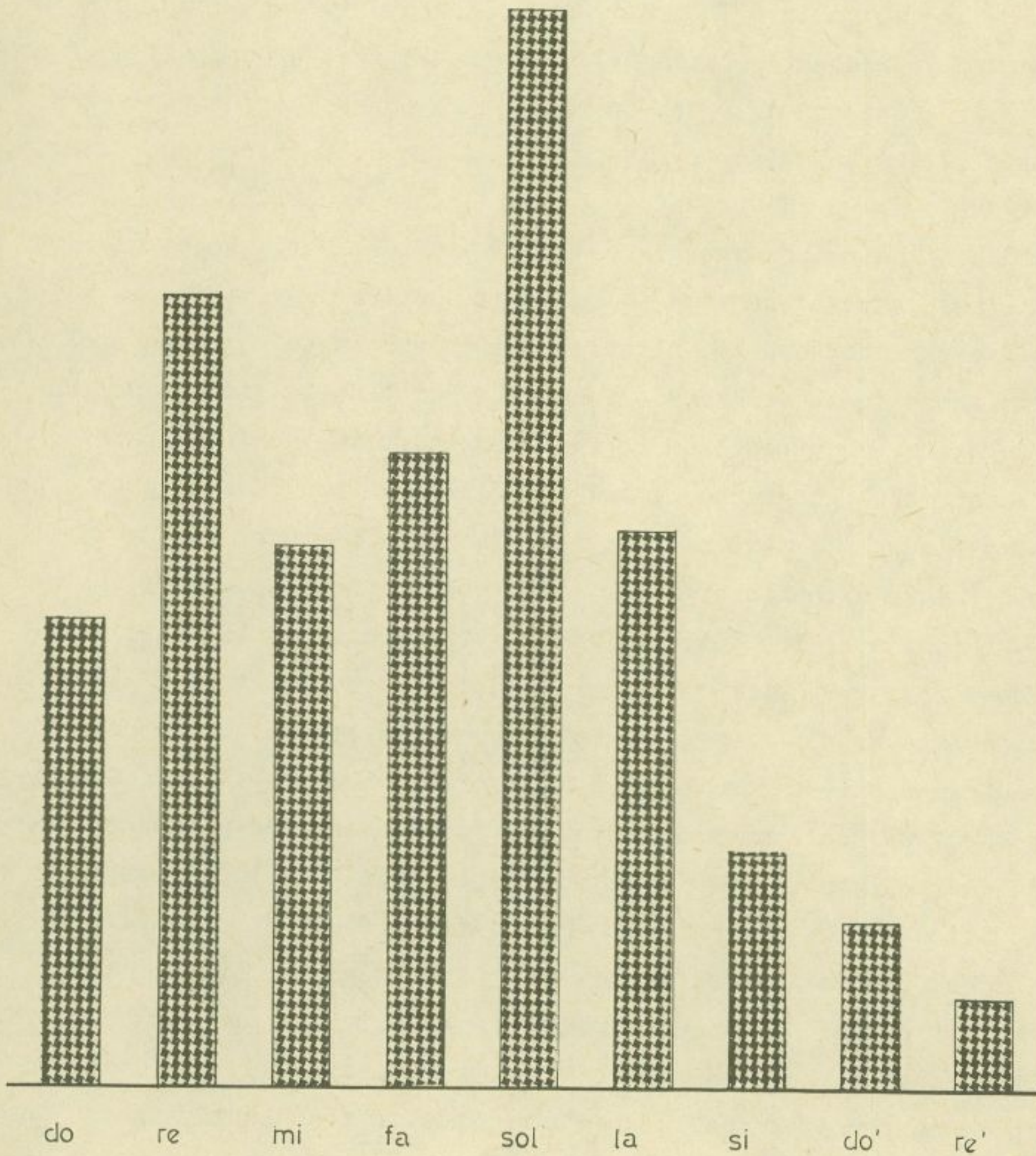
Figure 2 comprises two groups of summations, made for each one of the four groupings examined: A = the major; B = the Mixolydian; C = the Dorian; and D = the *hedjaz*. The solid columns give the total recurrences of notes in percentage for complete melodies, while the stripped columns indicate the total recurrences of notes in opening and concluding phrases only. It is easy to see that there is no real difference between the curve of one group and that of the other. In other words, the opening and concluding phrases represent a quite reliable statistical presentation of the total recurrence of notes in the entire tune. We see that each mode is characterized by its own specific note recurrence diagram. Figure 3 shows the breakdown of note recurrences with the opening and concluding phrases given separately. Despite the similarity of these summations with those of the entire tune, there is a difference between the recurrence of notes in the opening phrase and those in the concluding phrase. For example, in the Dorian songs, the recurrence of *re* is predominant in the first phrase, whereas the recurrence of *sol* and *la* in the concluding phrases is almost equal to that of *re* , even though some tunes in the Dorian mode begin with higher notes. The column on the far left, marked "0", indicates the number of motifs that contain two notes only. These zeros arise from the registration system mentioned above, in which the middle number received the value of zero when the motif contained only two notes. This information was obtained as a by-product of the summations on note recurrences; and although it is not directly concerned with this aspect, it is an interesting addition to the characterization of the modes. For example, the zero column is longest in the major key songs, because of the greater number of two-note motifs, most of which are built on 3rds. Thus, one of the conditions that we would have had to dictate to the computer if we had wanted to compose a tune typifying any one
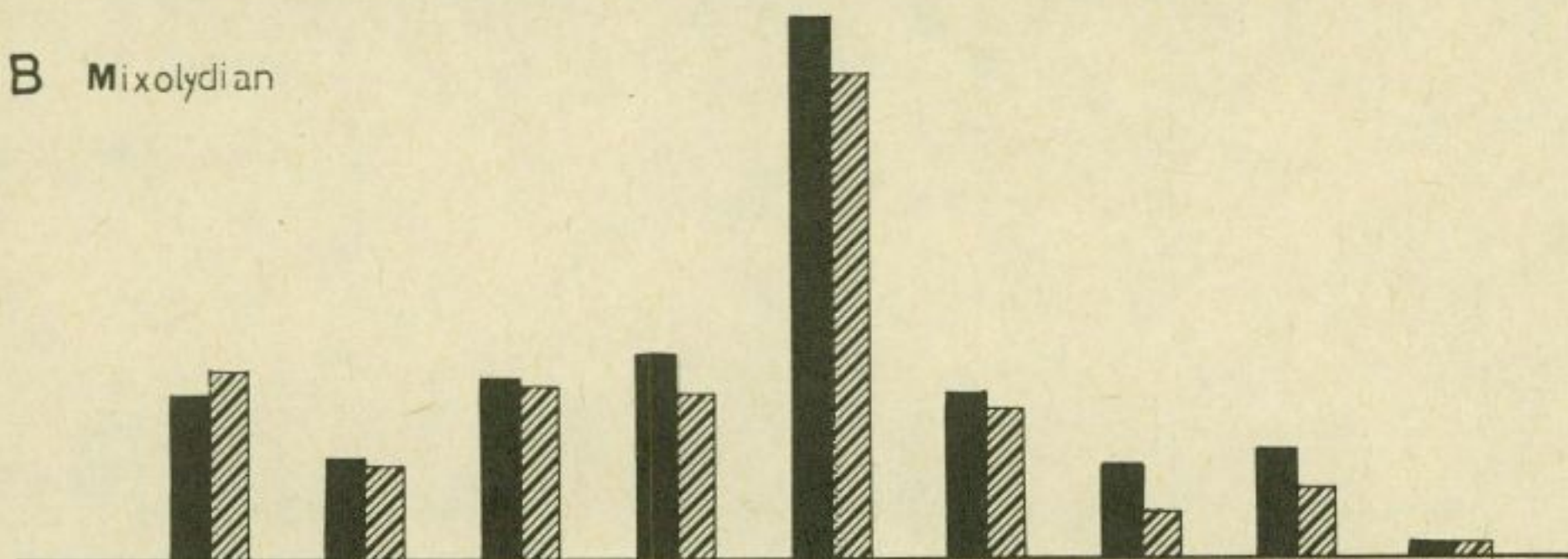
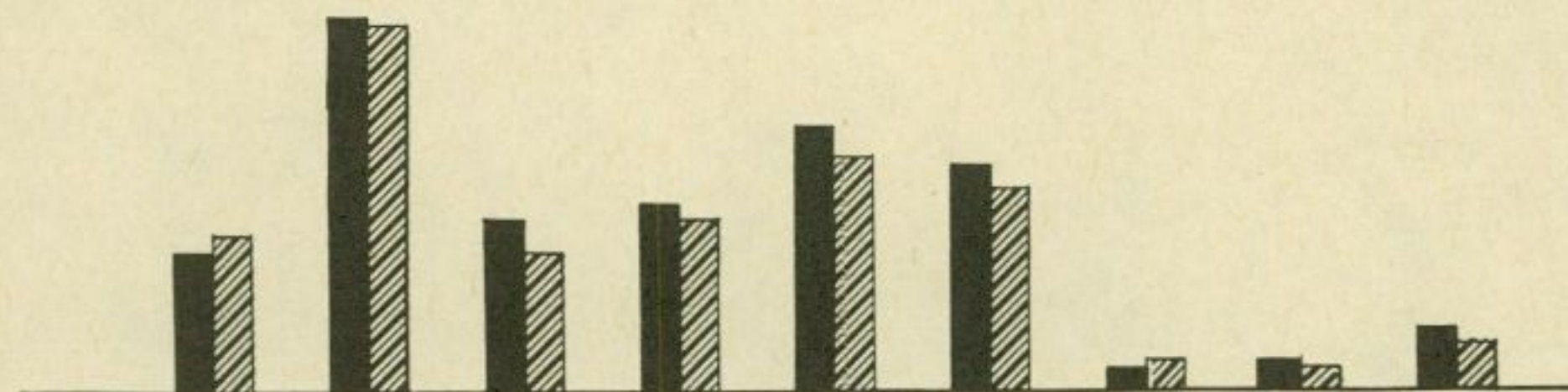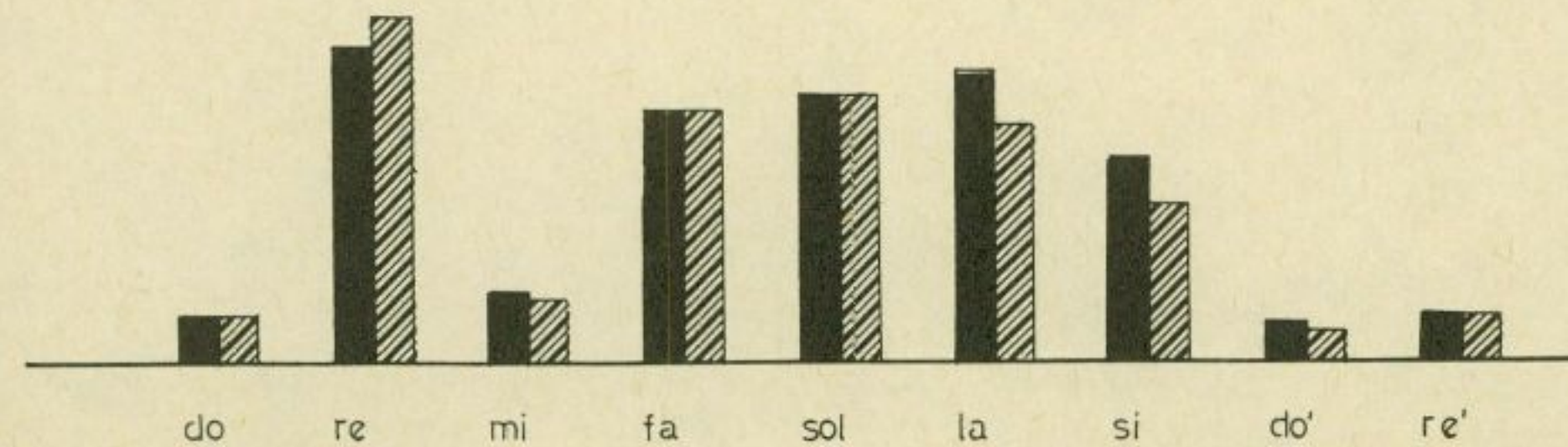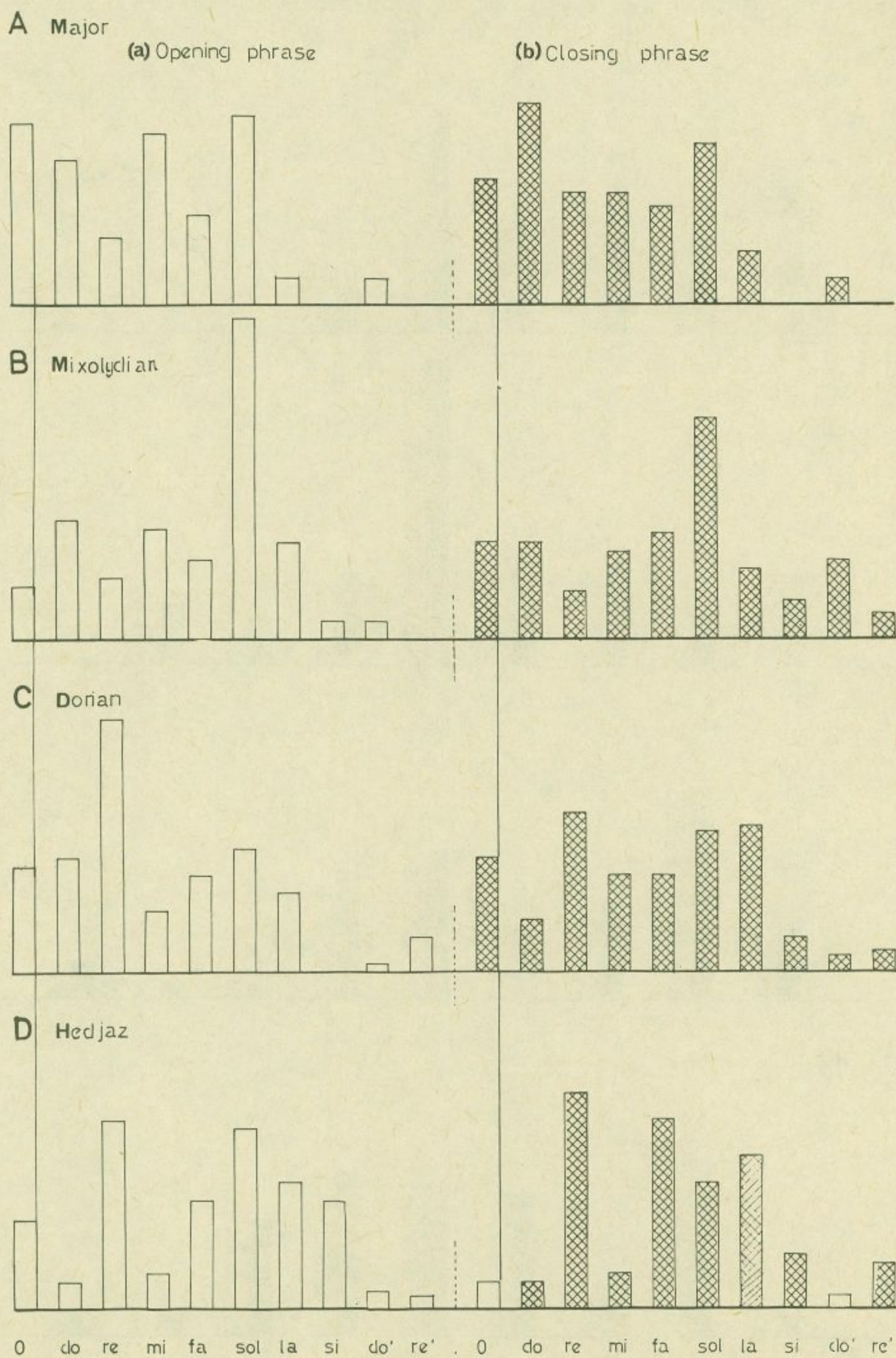Fig. 2 Summary of the frequency of occurrence of notes in each of the four modal groupings.

Fig. 3   Summary of the frequency of occurrence of notes in:
(a) the opening phrases; (b) the closing phrases.

A Major

(a) Opening phrase   (b) Closing phrase

B Mixolydian

C Dorian

D Hedjaz

0 do re mi fa sol la si do' re' . 0 do re mi fa sol la si do' re'
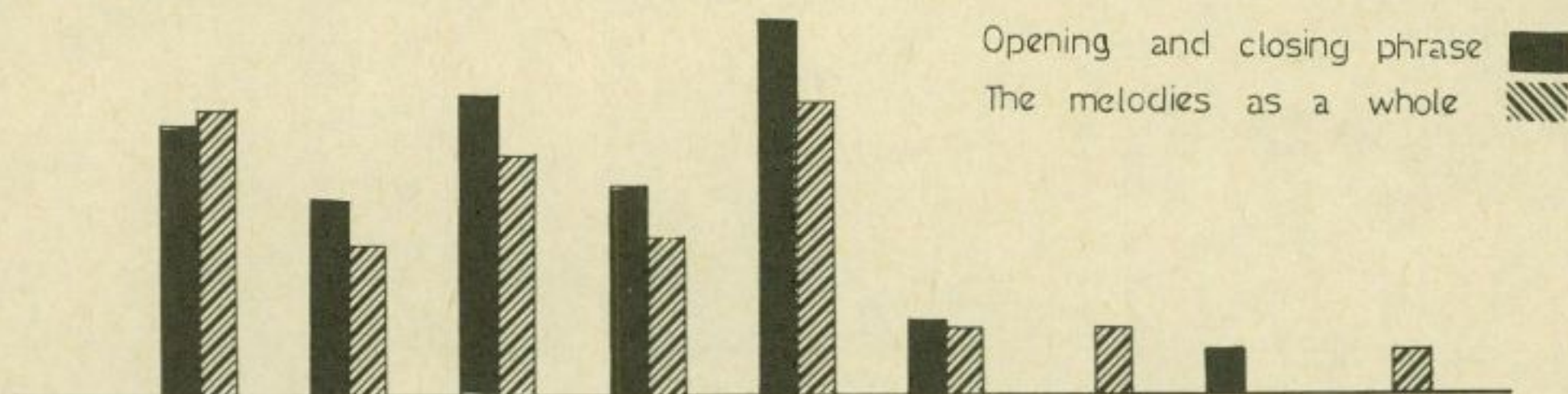
of the four groupings would have been the characteristic statisti-
cal presentation given above[11].

So far we have discussed the statistical summations of the
notes, without reference to their location in the melody. Of
course, one cannot consider any music without taking into account
the dimension of time, so that the "before" and "after" are of
importance. Actually the importance of the "before" and "after",
i.e. the order of the notes on a time axis, is not self-evident.
The importance of the time sequence reached its peak in the
musical expression of the Western world, particularly in "classi-
cal" tonal music based on the major and minor scales and on
functional harmony. In Western music of other periods and especial-
ly in non-Western music, the importance of temporal order is
considerably less. For example, in Oriental music the logic of
organization is different. The mosaic principle dominates, i.e., a
fairly free combination of events where the order can change[12].

In our case it is interesting to see whether there is any
regularity in the occurrence of preceding or subsequent notes. For
example, in the Dorian mode, are all notes likely to appear after
re, or only some of them? What is their frequency of occurrence?
Or, which notes is *re* likely to follow? The same question can be
posed regarding triplets (i.e. groups of three notes). For
example, which notes are likely to appear after the *re-mi* pair,
and which will precede it? One could go on until all the possibi-
lities have been exhausted. Let us keep in mind that the number
of possible pairs is eighty-one, and that there are 729 possibili-
ties for triplets, while the number of arrangements for groups of
ten notes runs into millions!

The summations we reached, with the aid of the computer, concern
only the pairs and triplets that characterize each of the modes.
In this report we shall give the summations of pairs only, and

attempt to show how these summations taken alone can contribute toward characterizing a given mode.

Figure 4 gives the summation in percentages of the frequency of occurrence of notes which precede or follow each of the notes of the scale, in each of the modes studied. In Figure 4A, the notes of the tunes in the major mode preceding *do*, *re*, etc. are indicated on the right. Figure 4B contains the same information for the Mixolydian tunes, Figure 4C for the Dorian tunes, and Figure 4D for the *hedjaz* tunes. A closer look at each diagram will, generally, reveal their marked symmetry. There is no great difference between the columns on the left and on the right, i.e., there is not much difference in the frequency of occurrence for notes preceding or following a certain note. Of course, there are exceptions, such as in the Mixolydian tunes of Diagram 4B, where *mi* usually precedes *re*, while *do* usually follows *re*. On the other hand, there are considerable differences in the diagrams depicting the various notes in each group. For example, in the same Mixolydian tunes, almost all the notes appear before and after *sol* (with the exception of *re*), while the notes that appear before and after other notes are very limited. The main distinction is found by comparing the four modal groupings, whose broad and typical profile clearly distinguishes one mode from the other, particularly with regard to the relationship indicated in Figure 4.

Although we did not find great differences between the "before" and "after" notes in the course of examining neighbouring notes or pairs of notes, we did find differences in our examination of triplets, i.e. pairs of notes that precede and pairs that follow each of the notes in the scale. In the summation of triplet groupings, the "allowed" and "forbidden" were more conspicuous, e.g. in the Dorian, after the melodic interval *re-la* the *sol* will almost always appear; the *re*, either higher or lower, sometimes;

Fig. 4a Summary of the frequency of occurrence of: (a) the notes
preceding and (b) the notes following each of the scale
notes in the major melodies. The scale notes are given in
the center of the figure. The solid circles emphasize the
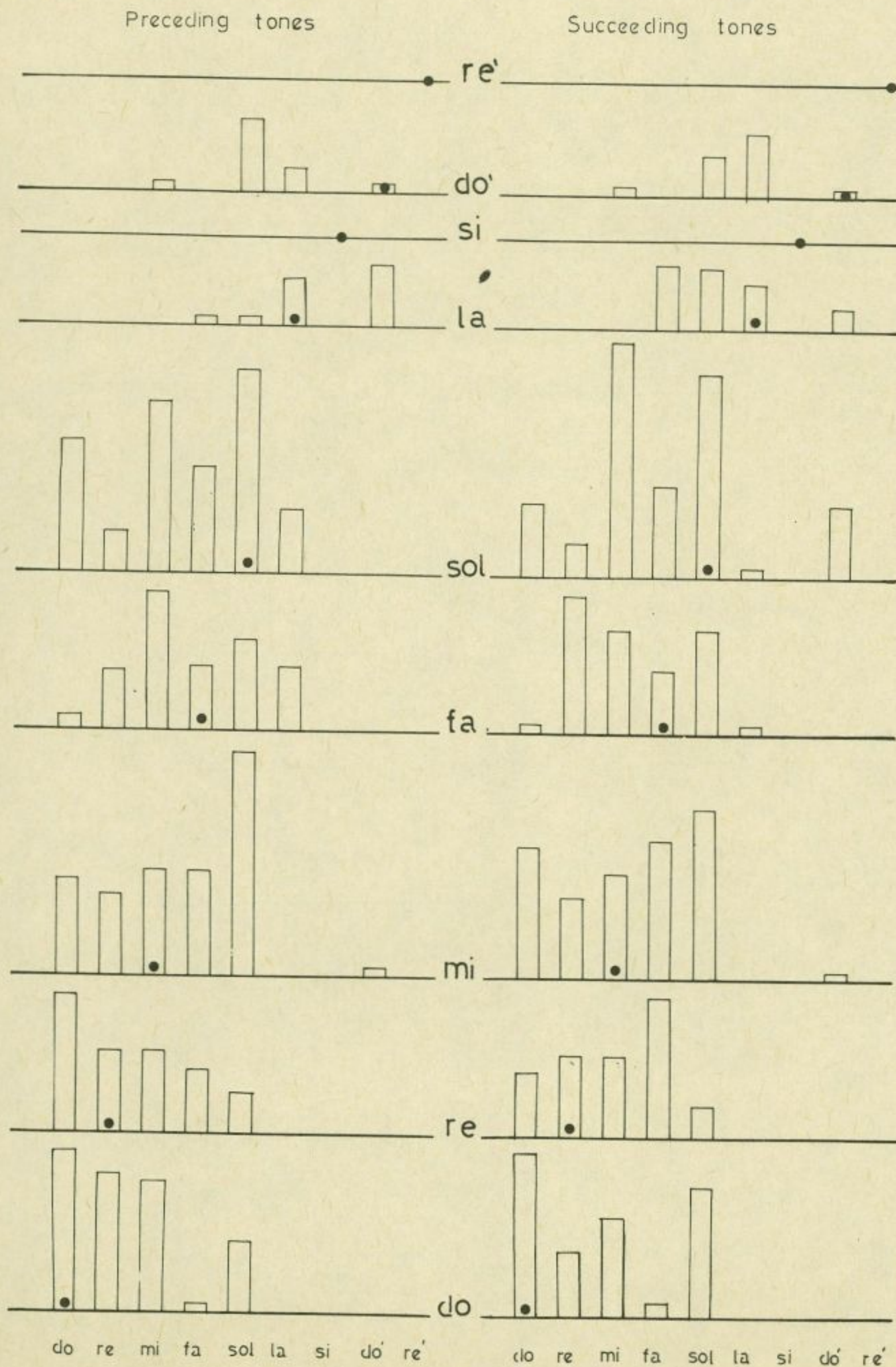identification of notes which precede and follow the
corresponding scale notes.

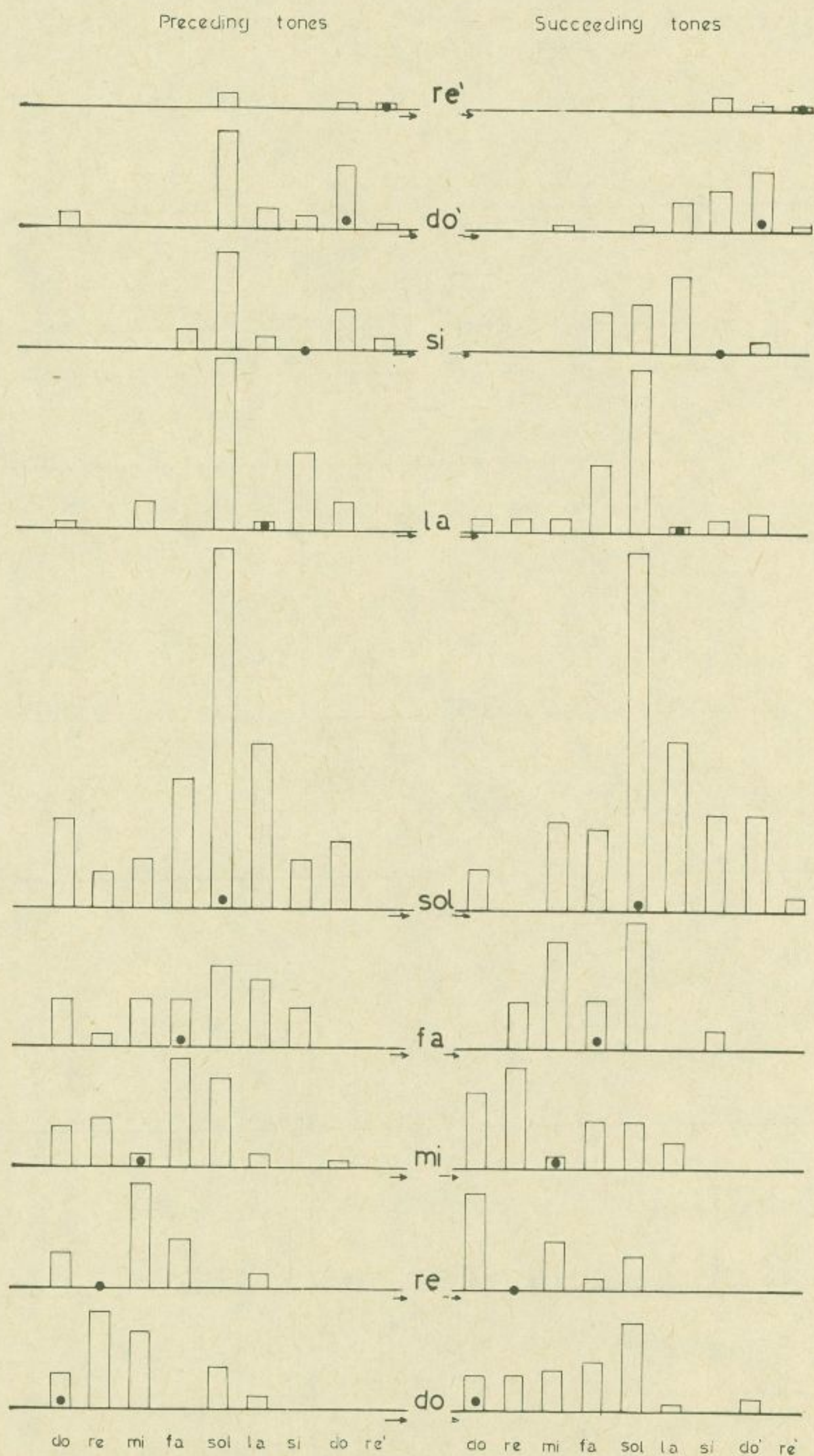Fig. 4b Same as Fig. 4a, but for Mixolydian melodies.

B Mixolydian

Preceding tones   Succeeding tones

re'

do'

si

la

sol

fa

mi

re

do

do re mi fa sol la si do re'   do re mi fa sol la si do' re'

Fig. 4c Same as Fig. 4a, but for Dorian melodies.

C - Dorian
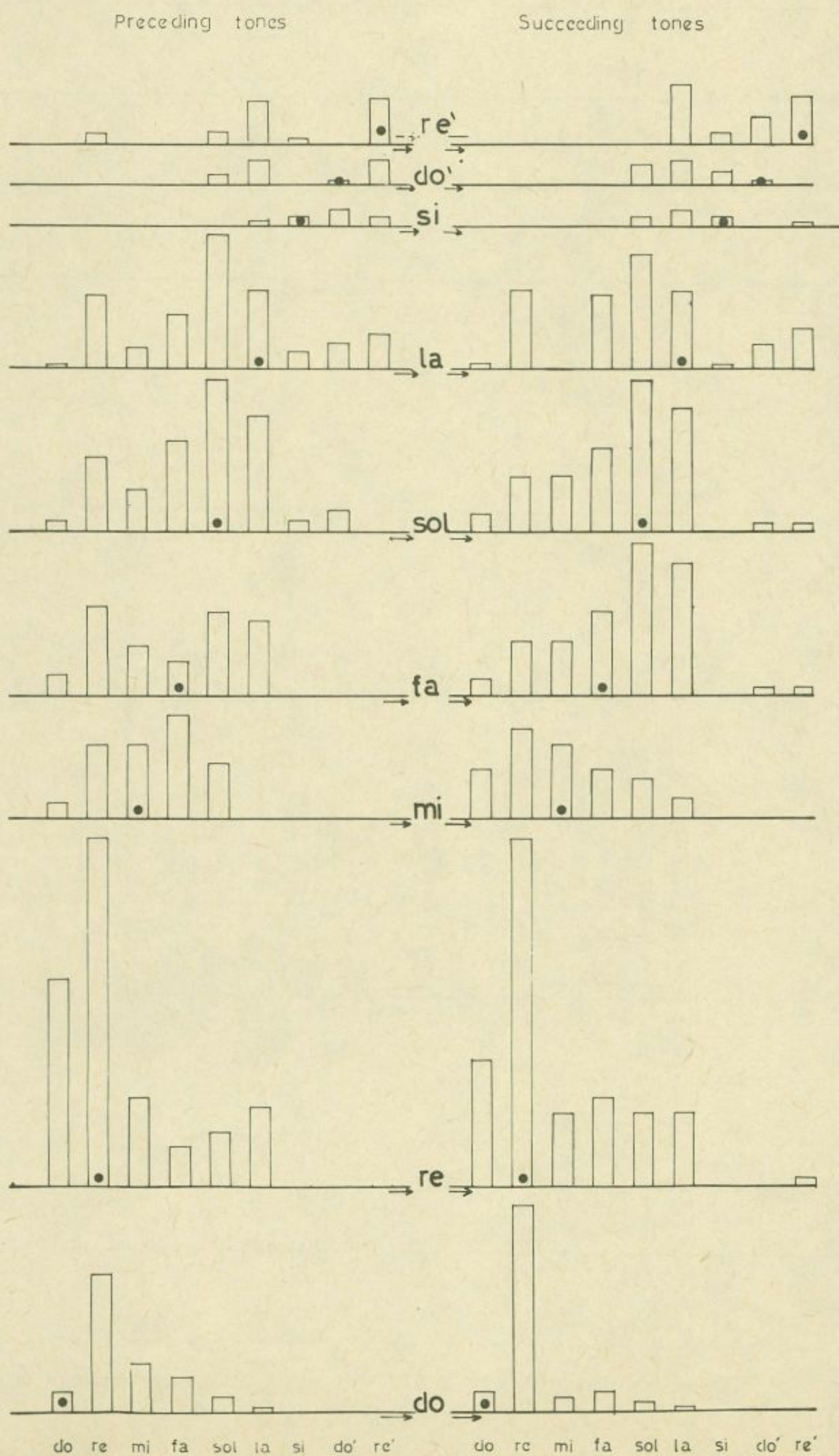
Preceding tones   Succeeding tones

do re mi fa sol la si do' re' do re mi fa sol la si do' re'

Fig. 4d Same as Fig. 4a, but for Hedjaz melodies.
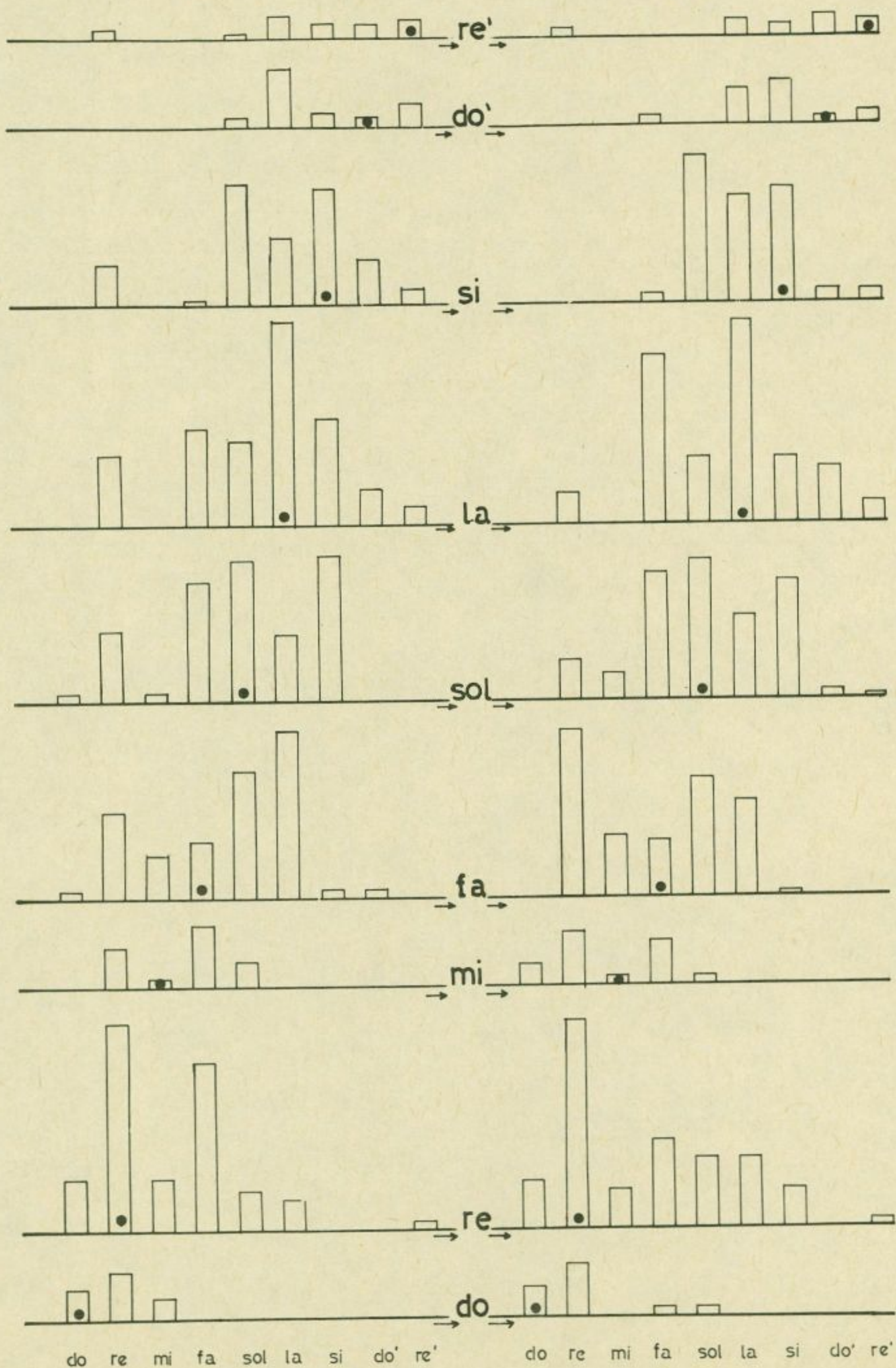
but the *fa* never. In contrast, in the *hedjaz*, after *re-la*, the *sol* will not appear; the *fa* almost always and *si-bemol* sometimes. We found that the behaviour of the "before" and "after" is dictated by typical statistical distributions.

In addition to the summation of the pairs and triplets we made a general summation of the order of notes in the first and last phrases. The number of possible arrangements of notes, for the first and last phrases alone, extends into millions. Therefore, it is obvious that a comparison of the songs from the point of view of temporal progression is possible only with the aid of the computer; but the operation is so complicated that a special programme must be developed to answer these specific needs. It is clear, however, that a comparison of the tunes from the point of view of note sequence, would permit a classification into similar groupings in accordance with this criterion. It would also be interesting to know of the relationship with groups representing other kinds of criteria.

The method we have employed is called Multidimensional Scalogram Analysis (M.S.A.). It was developed by Guttman and Lingoes, for the purpose of comparing and characterizing groups in which the sequence between the components is important (Guttman 1941; Lingoes 1966: 76-78 and 1968: 61-94).

We shall not describe in detail the complicated principles of the M.S.A. system. It is sufficient to remark that the system is expressed in diagram form by compiling various rows of events according to their similarity in temporal sequences. In our case, each row of events represents an individual tune, and groups of rows represent the similarity of their order of notes. The compilation, according to similarity, can be represented diagramatically in two or more dimensions. In our work we have used two dimensions only for a description of the affinity among the tunes.

First, we compared all the tunes and came up with a distribution
of dots representing the tunes which were collected according to
affinity of note sequence. We found four concentrations of dots
corresponding to the four modes. The existence of this affinity
between the concentrations, and their overlappings is indeed
interesting. Secondly, we made a separate examination of each
mode, comparing the various tunes within it. In the present
research, comparison among the tunes was based on a choice of
twenty-eight notes from each tune; fourteen for the opening and
fourteen for the closing phrase. In other words, twenty-eight
events (or notes) to designate the total melody. Considering the
millions of possible arrangements, twenty-eight is a very large
number. It should be kept in mind that it was dictated by the
system used.

As a result of this examination, a comprehensive distribution
of dots, indicating affinity among the tunes, was obtained. In
addition, twenty-eight individual distributions were obtained,
corresponding to the twenty-eight events. Each distribution indi-
cates which note appeared in each of the events in the tunes, e.g.
in the first distribution, the opening notes of each tune are
given; in the last distribution all the final notes; in distribu-
tion No. 14 - all the notes on which the first phrase ends, etc.
From the multitude of interesting distributions we chose one
example - Figure 5, which describes comprehensively the affinity
between all the tunes in the Mixolydian mode. In this figure we
can distinguish among three concentrations: every dot in the
distribution represents a specific melody and is indicated by a
number, so that one can identify which melody is represented by
which dot. The list under Figure 5 indicates the names of the
songs from the three collections indicated by ● , ◐ or ✪
without stating which song belongs to which designated symbol.

Fig. 5 An M.S.A. comparison between the Mixolydian tunes according
to their similarity in the time order of their notes. Each
circle in the diagram represents one tune.
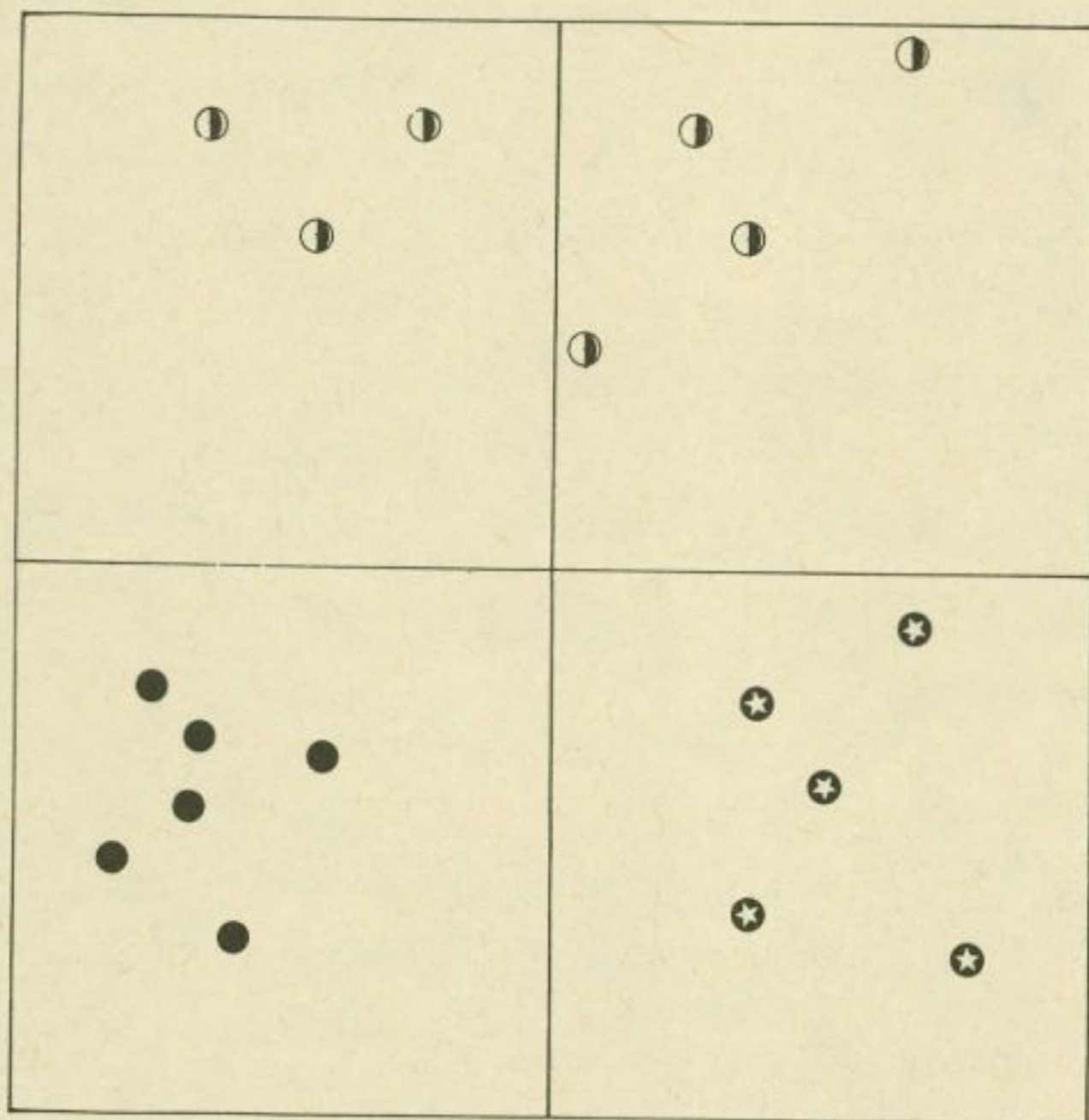
◖	^cAL GEVA^c RAM	(Y.Admon)	
	SALLÊNÛ	(Y.Admon)	● LANÛ HAK-KOAH (A.Amiran)
	ŠÎR HAN-NÔDED	(S.Levi)	ḤÛLÛ MEḤÔL HA-HÔRAH (M.Vilenski)
	KEN YŌVEDÛ	(S.Levi)	HAVAH NISTÔVEVAH (B.Avigayil)
	^cUZÎ WE-ZIMRAT YAH	(M.Shelem)	RIQQÛD SIMḤAH (J.Stuchevski)
	MEḤÔL HA-AVÎV	(Y.Hadar)	ḤAD GADYÄ (Y.Admon)
	HALLELÛYAH	(A.Ma'ayani)	

✪ KEN YŌVEDÛ (U.Giv'on)
TEN KATEF (Y.Ze'ira)
^cADARÎM (M.Shelem)
^cEMEK (M.Lavri)
HÔDAYAH (A.Boskovitsch)

The collections, of course, resulted from the calculations made by
the computer. A cursory survey will show that the lower-right
collection, indicated by ⭐ is characterized by melody curves
which begin and end on *sol*, whereas the lower-left collection,
indicated by ⚫ is characterized by varying melodic curves, which
begin and end on *do*. In the upper collection, marked ◑ , the
curves show resemblances to those of the collection of the lower-
right as well as to those of the lower-left. Without going into
the significance of the calculation, which seems to us of extra-
ordinary interest even with regard to the material known to us,
let alone unknown material, we can only point out the importance
of *order*, not only of notes, which was discussed here, but also of
other events.

INFORMATION REGARDING STYLE ON THE BASIS OF
PRE-DETERMINED QUESTIONS

We mentioned earlier that each tune was subjected to a large
number of questions. In our case, the Hebrew song derived from
written sources, where there are no problems regarding variation
in performance nor questions relating to the text underlay[13], the
song had to answer fifty-four questions, each having nine possible
answers. Generally, the questions were concerned with the follow-
ing subjects: *ambitus* and *tessitura*; structure and form; number of
sub-tunes within a given melody, their exact or varied repetitions
and interrelationships; intervals, their frequency and location in
the melody, and the appearance of the triad; pivotal tones, their
number and hierarchy of importance, their tasks in the melody and
their relationships to other tones (tones of repose and recitation
tones); final tones (*finalis*); motifs that make up the melody,

their number, their characteristic intervals and their location in
the melody, either at the opening, middle or conclusion, or
various combinations of these; type of combinations between the
motifs, and the detail of concluding and opening motifs; the
various phenomena of the sequence. The subjects connected with
the temporal factors comprise: number of measures in the melody;
number of notes to the measure - maximum and minimum and the
difference between them; the different meters; existence of up-
beat; appearance of various rhythmic formulae; number of different
time values; existence of long notes and their location in the
melody and the relationship between the long and short notes. The
full questionnaire is given in the Appendix.

We obtained answers divisible into three sections: *a*: informa-
tion regarding each of the sets of musical components known to us,
e.g. everything connected with the rhythmical organization, the
structure, and the motific material in each song group. *b*: infor-
mation regarding relationship and interrelationship among the
parameters, if any. For instance, does the greater number of sub-
tunes in the song necessarily indicate a greater number of motifs?
Is the number of different temporal values in the song related to
the difference between the maximum number of notes per measure
and minimum number of notes per measure, etc.? *c*: information on
what is or is not specific to each of the modes, i.e. those
characteristics that are only peculiar to the songs of a certain
mode, and characteristics that are common to two modes only, while
the other two display a different common characteristic. Similarly,
it is possible to find characteristics common to three modes, as
well as to all four. Obviously, in the last case those character-
istics in which there is no modal singularity are indicated.

We shall refrain from detailing all the results of this examina-
tion; however, we will cite a few examples from each of the three

sections of information, in order to demonstrate some of the
results which could not have been obtained so reliably without the
computer.

1. Examples from musical parameters

An examination of all the *intervals* revealed that various
ascending or descending 3rds were present in every tune, irrespec-
tive of the mode, though their location was confined to the modal
characteristics. In the major or the *hedjaz* we found the 3rds
distributed throughout, in the opening, in the middle and between
the phrases. In the Dorian and Mixolydian tunes, the 3rds appear
almost uniquely in the middle of the phrase, but not at the
beginning or between phrases. On the other hand, the modes differ
as far as 4ths are concerned, with particular regard to frequency
and location. In this respect there is also a division between
major and the *hedjaz*, as compared to the Dorian and Mixolydian.
An examination of *syncopation* reveals that it is found mainly in
the Mixolydian mode, but not at all in the major. Of course,
there are several kinds of syncopation. The number of their
occurrences may be low (only once in a short tune of about ten
measures - or twice in a longer tune) or high and of great signifi-
cance. We have classified the occurrences of syncopation in
hierarchical order, according to frequency: 1) A low number *of
one kind* only, e.g. ♪ ♩ ♪ ; 2) A high number *of one kind*; 3) A
low number of *various kinds*, e.g. ♪ ♩. ; ♫♪ etc.; 4) A high
number of *various kinds*.

The results of our examination were as follows: In the major,
there was no syncopation; in the Dorian, 57% of the songs had no
syncopation, while of the others, 29% contained type 1, and 14%
type 2. In the *hedjaz*, 63% had no syncopation, 19% had type 1,

16% type 2, 6% type 3 and 6% type 4; in other words, many syncopa-
tions of various types. The Mixolydian was the richest in syncopa-
tion, 67% (remembering that the "Horas" in the minor scale, which
are rich in syncopation, were excluded).

It should be pointed out that characteristics in general are not
defined in total percentages of one hundred percent. While
theoretical concepts are generally defined in an absolute manner,
in practice their full representation is rarely found. There is a
kind of distribution in the appearance of each of the character-
istics. The measure of distribution can be large or small, and in
accordance with this, the characteristics are more or less deter-
mined. It is possible that the measure of distribution may be of
significance to this or other kinds of music.

As for the percentages given above, we are aware of the fact
that their meaning is not immediately comprehensible. The number
of percentages, of course, are checked for their statistical
significance.

Comparisons between the modes can be made by numerical quanti-
ties and by distribution, expressing their characteristics. For
example, our investigation of syncopation revealed that it occurred
in a greater percentage of songs in the Dorian mode, but only as
types 1 and 2; in the *hedjaz* the percentage was smaller, but it
included all four types. One could say that the majority of the
musical parameters are more clearly defined in the Dorian than in
the *hedjaz* mode, whose characteristics are widely distributed,
representing a measure of greater freedom in the use of the musical
parameters. This is characteristic for Oriental music. It follows,
therefore, that the computer confirmed the phenomena which one
would have expected to find in the *hedjaz* melodies because of
their Oriental origin. We give below a number of diagrams which
render summations of the musical characteristics. Figure 6
illustrates the appearance of various intervallic motifs, motifs

Fig. 6 Summary of the different motifs in each of the four modes built upon: (a) dichords; (b) trichords; (c) tetrachords; and (d) pentachords.
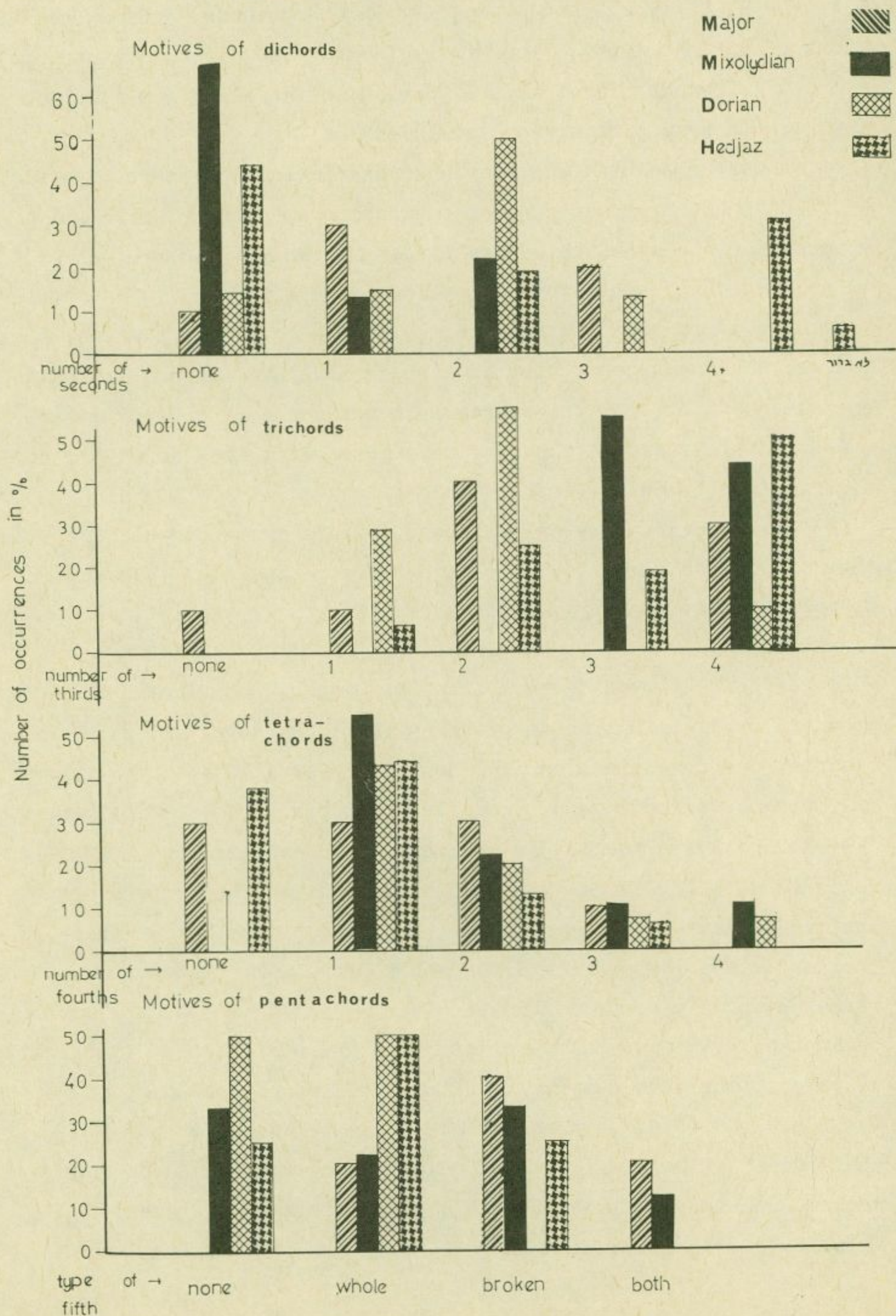
of 2nds, 3rds, etc. This figure is divided into four sections, of which No. 1 (the upper) represents the appearance of the motifs of 2nds; No. 2 - of 3rds; No. 3 - of 4ths and No. 4 - of 5ths. Each of the four kinds of motifs may or may not appear in a certain tune, built either on one note only or on several notes. For example, in a certain song there might occur two kinds of motifs of 2nds, e.g. *do-re* and *fa-sol*. A description of this is found in the horizontal line that indicates the number of different notes in which the motif of a specific interval appears. This number can also be "zero", i.e. no motifs of this type appear. As far as the 5th is concerned, the significance of the line is different, because the motif of the 5th insofar as it appears, is generally not built on different notes. Still, it is interesting to know whether the motif appears as a complete pentachord or as a combination of trichords. A further distinction made in this diagram concerns the different modes, each represented by a typical model. In this way, one can easily identify the modes and compare them as well as the motif types. It becomes clear from these diagrams that the motif of the 5th is found mainly in the *hedjaz* and major modes, where in the majority of cases it can be broken down into combinations of trichords. This occurs in 40% of the tunes in the major mode. In only 20% the motif of the 5th is found as a pentachord, and in the remaining 20% as pentachord and trichord together. In contrast, 50% of the Dorian songs do not have the motif of the 5th, and the other tunes have the pentachord. Motifs of 2nds are found in larger quantities in the Dorian and in smaller quantities in the Mixolydian modes.

Figures 7 and 8 illustrate the density of notes in time. Figure 7 illustrates the question of the temporal distribution of notes in two ways: 1) by the number of different time values in the melody (Fig. 7a) and 2) by the relationship between the longest

Fig. 7 Number of different time values and their appearance in the four modes.
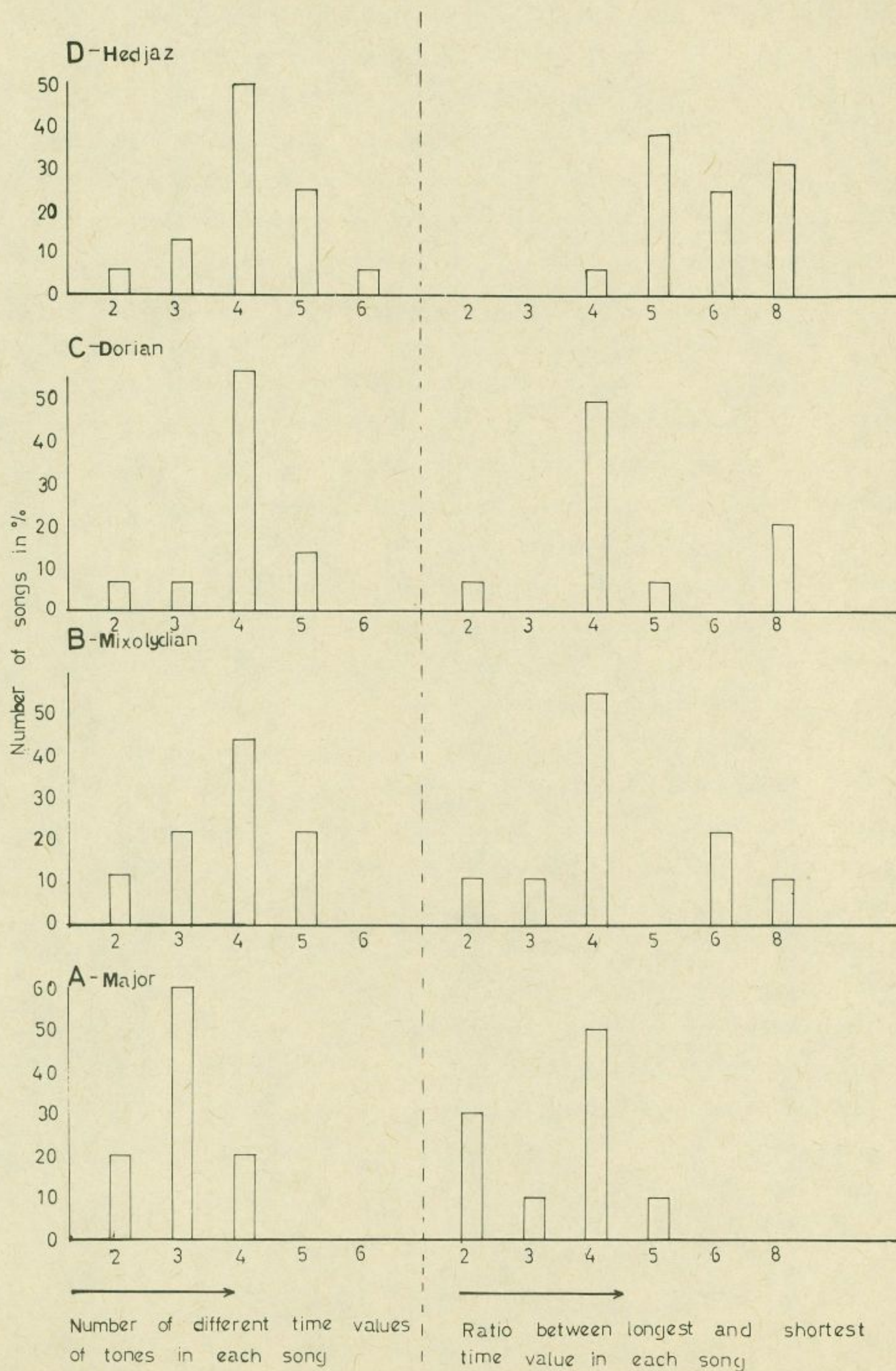
Number of different time values of tones in each song

Ratio between longest and shortest time value in each song

Fig. 8 Density and distribution of notes in the measures according to: (a) the maximal and minimal numbers of notes in a measure in each tune of the four modal groupings; (b) the difference between the maximal and minimal numbers.
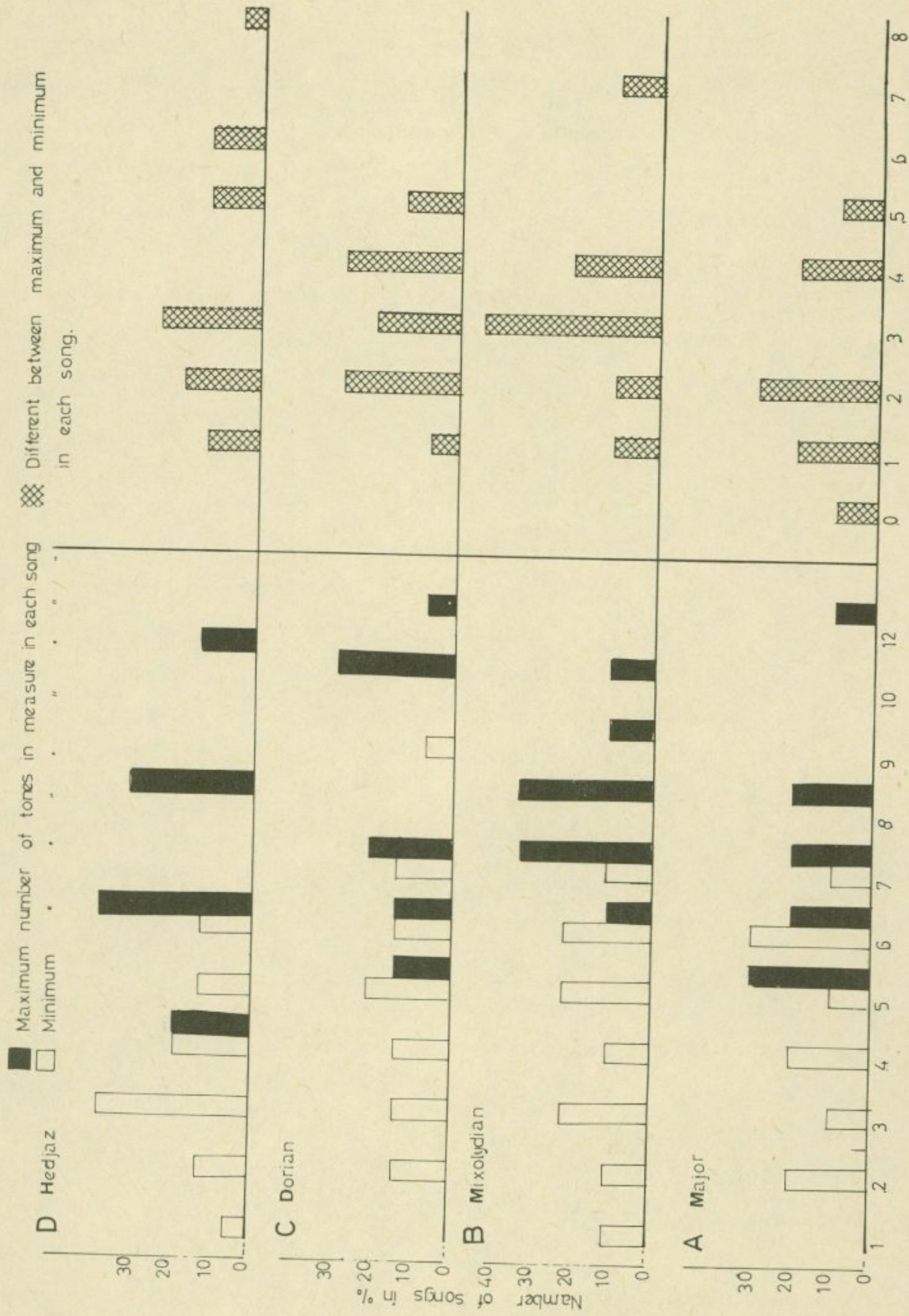
and the shortest notes in each of the melodies, except in cases
where the last note, being the only long note in the tune, is not
taken into account. These summations, like others not listed here,
are important in clarifying the significance of the above factors
and the degree of their influence in the moulding of the musical
style. In Figure 7a we see that the songs in the major mode are
exceptional in comparison with the songs of the other three modes,
in that they have the lowest quantity of time values. About 60%
of the melodies are composed of a combination of notes of three
time values, and 20% of only two. The other three modes resemble
each other in the distribution of the quantity of different time
values, the most frequent quantity being 4, and the maximum 6.
From Figure 7b, it appears that the *hedjaz* tunes are exceptional,
in that the ratio of the longest note to the shortest is higher
than in the other modes. The ratio is lowest in the major.
Separate examinations of the longest and shortest notes do not give
us any information about the relationships between the short and
long notes. In Figure 8, the minimum number of notes in each
measure is designated in the blank columns; the maximum, in the
solid columns. These maximal and minimal designations are given
for the tunes in each of the four modes. The difference between
the maximum and minimum numbers in each song is given in the lined
columns. In contrast to Figure 7, where a clear distinction
became apparent concerning the relationship of the modes to the
examined musical parameters, in Figure 8 the difference between
the modes is not striking. The smallest difference between the
maximum and minimum is in the major, and the greatest is in the
hedjaz. The greatest distribution of this characteristic is also
found in the *hedjaz*. We are thus able to present all the musical
parameters whose manner of appearance in the various modes was
summarized in exact numbers. Some of the summations are of signi-

ficance in regard to the modes, while summations not correlated
with modes can give us much information about the general charac-
teristics of the entire corpus of songs.

2. *The connection between parameters*

Another important aspect in the understanding of the musical
parameters and their contribution to the composition is the exami-
nation of the relationships between the various parameters. From
such an examination we may discover the dependence or independence
of certain parameters and the degree to which one influences the
other. For example, the reply to the question regarding the
relationship between motifs of 3rds and motifs of 2nds is: in the
major and the Mixolydian, there is no relationship, whereas in the
Dorian and the *hedjaz*, an increase of one brings about an increase
of the other. From a number of such investigations, an interesting
picture developed regarding the melodies in the Dorian mode, in
which the smallest and typical motif, the dichord, serves as a
nucleus, so that every other motif is composed of the dichord plus
the complementary motif. This means that the trichord is composed
of two dichords; the tetrachord of a trichord plus a dichord; the
pentachord of a tetrachord plus a dichord. While this answer
agrees with the hypothesis that could have been formulated from
the beginning, as regards the Dorian mode, on the other hand *the*
answer to the question on the relationship between the pair of
parameters, i.e., the difference between the maximum and minimum
of notes in the measures (as indicated in Figure 7b) and the number
of time values (Figure 8) in the tune *is surprising*. It was hoped
that a direct link would be found, but there was in fact no
relationship between the two, although taken separately each has
an important significance in relation to the mode.

TABLE 1

A summary of the relationships (present or absent)*between pairs of components in the four modes. The numbers in parentheses refer to the questions (as they appear in the questionnaire given in Appendix I).

The Mode / Pairs of Parameters	MAJOR	MIXOLYDIAN	DORIAN	HEDJAZ
No. of tunes (1) No. of meas.(39)	Co-relation in small quantity	No relation	No relation	Co-relation
No. of tunes (1) No. of motifs (23)	Co-relation	No relation (there are common motifs in the various tunes)	Relation	Relation
Division of tunes (2) Interrelation of tunes (4)	No relation	No relation (no immediate repetition of phrases; common motifs serve as unifying material)	Relation (common motifs exist only between tunes divided into two parts and only at the end)	Relation (common motifs of all kinds, only in tunes divided into a,a)
Division of tunes (2) Immediate repetition (7)	A small relation (a little repetition - 20% - only at beginning of songs divided into two different parts)	Relation (67% repetition at beginning and/or end of song, mainly of tunes divided into two different parts)	Large relation (80% repetition everywhere in the song, divided into two different parts) tunes	No relation (little repetition with no relation to division of tunes)

Motifs built on trichords (25) Motifs built on tetrachords (26)	No relation, when there is one 4th; opposite relation, when there are several 4ths	No relation, when there is one 4th; co-relation when there are several 4ths	No relation Relation is unclear
Meter (41) Syncopation (51)	No relation (no syncopation)	No relation (only even meters, and much syncopation)	Relation (in duple meters; even meters syncopation may or may not exist; in other meters – no syncopation) Relation (in even meters syncopation in small or large amounts, may or may not exist)
Difference between maximum and minimum no. of notes in a measure (45) No. of different time values (51)	No relation (both are minimal in the major)	No relation	No relation
Difference between maximum and minimum (45) The relationship between longest and shortest note (51)	Co-relation	Co-relation	Co-relation

The meaning of the existence of a link between pairs of musical
parameters in the tunes of a particular mode is that the behaviour
of one parameter dictates the behaviour of the other in each of
these tunes. That is to say, when such a link does exist, one may
become familiar with one of the parameters as a result of knowing
about its link to another. The relationship is determined statis-
tically, so that it is possible that it exists only with regard to
part of the tunes, either a small part - under 30% - or a large -
above 75%. Accordingly, it can be said that the link exists on a
smaller or larger scale in the same mode. There can be various
types of relationships because of essential differences in the
parameters and because of the number of possibilities in which
every parameter may appear. A lack of relationship occurs when
one parameter is fixed - as far as a group of tunes is concerned -
and the other is not, and also, when both of them change indepen-
dently of each other. Sometimes it is difficult to define the
relationship or lack of relationship, and this results in a some-
what unclear situation. There may be special cases of a relation-
ship between parameters that are quantitatively expressed (e.g. by
their range, number of motifs, etc.): 1) when change in one para-
meter brings about a change in the same direction in the other -
in this case the relationship is called a "co-relation"; 2) when
the direction of change of one is opposed to the change in direc-
tion of the other, then the relationship is called "contra-
relation". A partial summation of dependency or lack of dependen-
cy between some of the parameters is given in Table No. 1. This
table can also provide information about the nature of the mode.
The possibly significant relationship between the various dependen-
cies may also be examined. An examination of this type raises
other questions that require separate discussion.

3. *The significance of mode*

In discussing the modes of the Hebrew song, we have chosen the melodies in the major as our basis of comparison. From the summations and the cross-relationships, it was found that the major tunes are differentiated from the others by the following characteristics: the *finalis* always functions as the lowest pivotal tone; the degree of separation between the motifs is the greatest; non-conformity to the symmetrical form is minimal; the maximum number of notes to the measure is the smallest, as is also the difference between the maximum and the minimum number of notes; the number of different time values is the smallest, as is the relationship between the longest note and the shortest; a note longer than four beats is found only at the end of the song; syncopation is not found; and the upbeat is the most prevalent. The number of measures is characteristic; the sub-tones do not serve as a basis for variations; and the formal division is typical. From this characterization we may deduce that the ideal tune in the major mode is symmetrical and balanced - an ideal much less typical of tunes in the other modes. The major mode tunes have characteristics in common with the *hedjaz* tunes, although the latter are completely different from the major in other ways. The common characteristics result from the implication of harmony both in the major and *hedjaz*, although the implication is different. In these modes, the triad appears in various ways, whereas in others it is not found at all. The motif of the 5th appears either in complete or broken form. The interval of the 3rd may appear anywhere, though in the Mixolydian and the Dorian the interval of the 3rd will appear mainly within the phrase, not at the beginning or between phrases. The frequency of the 4th in the major is equal to that in the *hedjaz*. The only meters used in both are 2/3 or

6/8, although the formal division of the *hedjaz* tunes is very different to those of the major.

The characteristics peculiar only to the Dorian are: notes of repose can be only pivotal tones; there are many motifs of the 2nd; the motif of the 5th is complete, and when it appears in broken form it is broken into a tetrachord and a dichord; at the opening there is never an interval greater than a 2nd. The Dorian tunes are the only ones for which we found a meter other than the duple and the compound 6/8 - the latter, incidentally, being completely absent. Their rhythmic patterns are clear and repetitious. Taking the M.S.A. findings into consideration, with regard to the rhythmic patterns the principle of the Dorian tune can be called additive, e.g. 2/8 + 2/8 + 3/8. In this case also we have referred to the characteristics specific to the Dorian; though we are aware that it displays other characteristics that are common to the other modes.

In this way, we find that each mode is unique and also has relationships with other modes. For example, the major and the *hedjaz* have a number of common characteristics; the Dorian and the *hedjaz* have other characteristics in common.

There is a marked difference between the Mixolydian and Dorian modes in contrast to the major and *hedjaz* taken together and separately. The Mixolydian mode has much in common with the major, and yet it is also unique in itself. Partial summations of the characteristics peculiar to each mode and characteristics held in common by each mode are given in Table 2, where three types of information are provided: a) each mode is compared to the remaining three; b) pairs of modes are compared to each other; and c) all the modes are compared together; in other words, all the songs that were examined.

All of these together give rise to interesting interpretations, both regarding the specificity and the interrelationships of the modes. Thus the modal framework was found to be highly defined in an interesting manner, reaffirming the concept "melody types" in relation to a good part of the Israeli folk-songs. These "melody-types", among other things, are marked by an Israeli stamp. However, we like to reiterate that our examination did not include the totality of the Israeli folk-songs; some of them can clearly be said to be less defined as "melody types". Nonetheless the fact that this is the case for large and important groups of songs is interesting.

TABLE 2

A. Characteristics typical of each of the four modal groupings. The numbers in parenthesis refer to the questions, as they appear in the questionnaire given in Appendix No. I (should be read vertically).

MAJOR	DORIAN	MIXOLYDIAN	HEDJAZ
Sub-division of tunes (2)	Location of common elements of the different tunes in the song (6)	Location of common elements of the different tunes in the song (6)	Location of common elements of the different tunes in the song (6)
Non-existence of variations of the tunes (3)	Internal cadential tones (21)	Total number of different motifs in the melody (23)	Minimum number of exact and immediate repetitions (7)
Existence of non-immediate repetition (8)	Number of motifs built on dichords (24)	Large ambitus (35)	Existence of exceptional divisions of tunes (2)
Location of finalis (22)	Motifs built upon tetrachords (27)	Much syncopation (50)	Maximum number of time values (51)
Motif built upon a pentachords (27)	Opening does not contain an interval larger than a 2nd (37)	Duple meter only (41)	Maximum proportion between the longest and the shortest note (52)
Type of relation between the motifs (31-33)	Existence of exceptional meters (41)		No relation between the following pairs of parameters:

a) Division of
   tunes (7)
I b) Existence of
      immediate repe-
      tition (7)

a) Total ambitus
   (35)
II b) Ambitus of the
      pivotal notes

Typical metric
patterns (47)

Non-appearance of
the trichord (38)

No deviation from
even symmetry (40)

Appearance of
upbeat (42)

The lowest of the
maximum number of
notes in a measure
(44)

Least difference
between maximum
and minimum number
of notes in a
measure (45), i.e.
tendency to equalize

Lowest number of
different time
values (51, 52, 53)

"Simple" rhythmic
patterns (47)

Little appearance
of syncopations (51)

B. Typical characteristics common to pairs of modes:

MAJOR–MIXOLYDIAN	MAJOR–DORIAN	MAJOR–HEDJAZ	DORIAN–HEDJAZ	MIXOLYDIAN–DORIAN
Pivotal notes (15–16)	Ambitus (35)	Appearance of 3rds in all locations (10)	Pivotal notes (15–16)	Much immediate repetition (7)
No connection between the pair of components:		Type of 4th (11)	Recitation tones (18)	Location of 3rds (10)
a) Number of motifs built on trichords (25)		Appearance of 5ths (13)	Appearance of a prolonged note within the melody (51)	Type of 4th (11)
b) Number of motifs built on dichords (24)		Existence of immediate sequence (28–29)		Appearance of 5ths (13)
		Appearance of triads (38)		Ratio between longest and shortest note (51)
		Duple and compound 6/8 meters (41)		

Ambitus (35) No. of pivotal tones (15)	Relation (for an ambitus smaller than an octave - only two pivotal tones; for a larger ambitus - two-four pivotal tones)	Relation is unclear	Mostly no relation	No relation
The ambitus of the tune (35) The range of the pivotal tones (17)	Relation (when the ambitus is an octave or a 9th - the range is an octave)	Relation (when the ambitus is up to an octave - the range is a 5th; when the ambitus is more than an octave, the range is generally a 4th - the lowest pivotal note jumps an octave)	Co-relation	No relation
Motifs built on trichords (25) Motifs built on dichords (24)	No relation	No relation	Co-relation	Co-relation

* Relationships here can appear in the following ways: no relation; co-relation; opposite relation; other relations in various degrees.

C. Characteristics common to all four modes:

1. Similar distribution in the number of different tunes in the different melodies in each of the modes (1).

2. Existence of several ascending and descending 3rds in half of the melodies (9).

3. The cadential motif contains an interval bigger than the 2nd and in another direction (36).

4. The degree of melismatic quality between 5-20% (46).

5. No relation between the pairs of parameters:
   a) Difference between maximum and minimum number of notes in a measure (45);
   b) Number of different time values in the melody (51).

6. Existence of co-relation between the following pairs of parameters:
   a) Difference between maximum and minimum number of notes in a measure (45);
   b) Proportion between the longest and the shortest note in the melody (52).

NOTES, REFERENCES, APPENDICES, ETC.

NOTES

1. Early summaries of musical research with the aid of the computer were given by Erikson (1968) and Cohen/Katz (1972).

2. A number of studies have already shown promising results utilizing the computer; see for example Selleck/Bekerman (19 (1965) and the bibliographies in *Computers and Humanities* (Queens, New York).

3. To mention but a few of the works that have dealt with what is called the Israeli song, excluding the various sub-ethnic musical traditions: Ben-Zion Orgad (no date); Bathja Bayer (1968); Menashe Ravina (1968); Herzl Shmueli (1968; 1971); Michal Smoira (1963). Shmueli's book on the Israeli folk-song (1971), which is the most comprehensive one hitherto, appeared after our present work was done. However, the problems dealt with in our study were not represented in his book.

4. We have already investigated both intonation and variation in performance as observed in the local Arabic as well as in various Jewish ethnic traditions. After the completion of similar research among various sub-ethnic groups, it will be possible to arrive at what we hope will be a common basis for research on the new Israeli and the traditional ethnic song, which will enable us to define the characteristics of each style, as well as to determine stylistic differences and similarities.

5. The *zarka* is one of the cantillation signs, the contour of which resembles the turn (∾). This contour appears frequently in Israeli folk-song.

6. Characteristic to the scales of each "mode" (or *maqām* or
   shtaiger) is the tetrachord called *hedjaz*, whose characteristic
   intervals comprise 1/2, 1 1/2 and 1/2 tones. This tetrachord
   forms the lower half of the scale.

6a. The bulk of songs in the minor scale, comprising a good part
    of the "Horas" and many other kinds of songs, were not in-
    cluded in our examination because we preferred to concentrate
    on the more modally defined and indigenous nature, though some
    of them were incorporated in the Dorian group.

7. See the list of songs for dances in Kadman (1969: 82-83; 89-
   91) and in the book on Solfège Instruction by Miriam Gross
   Levin (1953).

8. The note designations and their numerical configuration offer
   innumerable possibilities when subjected to various criteria.
   In music which is transmitted orally, the division into modes
   is not clear. Each system of notation has its advantages and
   disadvantages. Each emphasizes some things while ignoring
   others. The system in which all the concluding tones (*finalis*)
   are designated by the same note, emphasizes intonation while
   neglecting scalar relationships. On the other hand, a system
   which emphasizes absolute pitch overlooks the fact that
   absolute pitch is less absolute than supposed, at least in
   narrow range. As a matter of fact in most repertoires it is
   even not fixed in ranges exceeding the 3rd.
   While other systems exist, we have attempted to fix on a system
   that would best suit our needs. It should be remembered that
   in general our system is accompanied by graphical melody
   representations obtained with the aid of a melograph, which
   supplements the information about exact intonation. In
   addition to the graph, we examined absolute pitch and its

changes in repeated renditions of songs by the same and by different informants. However, in our examination of notated Israeli folk-song melodies, the problems connected with actual performance did not concern us. We organized the notated melodies of the four chosen modes so that the interrelationship among them would be emphasized by the recitation tone typical to all of them. If we designate this reciting tone as *sol*, then the *finalis* of the Dorian and *hedjaz* would be *re*; that of the Mixolydian and Major *do*, even though their scales are different.

9. Selection of the main notes for the representation of the song was not done by the computer (in many cases, the main notes represent all the notes, so that there are no additional notes).

10. It should be mentioned that the choice of the names of the notes in the scales of the *maqāmāt* was determined mainly in accordance with a fixed tone which is equivalent to our *sol*, one that generally serves as a note of repose or reciting tone. The task of the *sol* is parallel to that of the *la* in Greek music, the *mese*, i.e. the middle note of the Greater Perfect System, from which the Greek scales are derived.

11. From the above, it might be supposed possible to confirm the truth of the findings of the examination carried out with the aid of a computer by the opposite procedure, i.e. feeding the results into the computer in order to get a "typical" melody. However, this is not a simple matter, since, to begin with, we did not address ourselves to all possible factors, musical and non-musical, that enter into the making of a melody; moreover, factors generally remain that have not been considered or properly defined. For a discussion of these problems see Bar-Hillel (1960: 160-161), in which he discusses the problem of

translations with the aid of the computer. The simpler the
style of a certain repertoire, the greater the degree of
accuracy or faithfulness to the style in the "creations" of
the computer. Possibly the degree of faithfulness of the
computer "creation" may indicate the degree of complexity of
the style.

12. This principle is found also in contemporary music, and in
planning their works, many composers make conscious use of
the time axis turned in various directions - forwards, back-
wards, upwards, and downwards. See for example the article on
Stravinsky by Edward T. Cone (1968).

13. In music which is based upon improvization, as is in fact the
greater part of the music of the area, the improvization
applies equally to the texts, and it is difficult to separate
the two. The two are so closely related to each other that
many of the performers are unaware of the independent existence
of each. In the Israeli song, on the other hand, the texts
are written out and are fixed, and may exist independently of
the music.

FIGURE CAPTIONS

Fig. 1   Summary of the frequency of occurrence of notes for all
          melodies of the combined modal groupings.

Fig. 2   Summary of the frequency of occurrence of notes in each
          of the four modal groupings.

Fig. 3   A summary of the frequency of occurrence of notes in:
          a) the opening phrases;
          b) the closing phrases.

Fig. 4a   Summary of the frequency of occurrence of:
          a) the notes preceding and b) the notes following each of
          the scale notes in the major melodies. The scale notes
          are given in the center of the figure. The solid circles
          emphasize the identification of notes which precede and
          follow with the corresponding scale notes.

Fig. 4b   Same as Fig. 4a but for Mixolydian melodies.

Fig. 4c   Same as Fig. 4a but for Dorian melodies.

Fig. 4d   Same as Fig. 4a but for Hedjaz melodies.

Fig. 5   An M.S.A. comparison between the Mixolydian tunes accord-
          ing to their similarity in the time order of their notes.
          Each circle in the diagram represents one tune.

Fig. 6   Summary of the different motifs in each of the four modes
          built upon a) dichords; b) trichords; c) tetrachords;
          d) pentachords.

Fig. 7   Number of different time values and their appearance in
          the four modes.

Fig. 8   Density and distribution of notes in the measures accord-
          ing to:
          a) the maximal and minimal numbers of notes in a measure
             in each of the tunes of the four modal groupings;
          b) the difference between the maximal and minimal numbers.

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QUESTIONNAIRE ON THE ISRAELI SONG, CODIFIED FOR THE COMPUTER

Each question has a number of possible answers - designated in the numerator.
Each number in the denominator under each possible answer represents the
computer code number of the answer.

Formal structure of the melody

1. Number of tunes in the song:

    a) clearly defined tunes*:

one	two	three	four
1	2	3	4

    b) not all the tunes are clearly defined; possible variation or prolonga-
    tion will be designated by +

one +	two +	three +	four +	more than four
5	6	7	8	9

2. Sub-division of the tunes:

not divisible	divided into two different parts	divided into a,a'	divided into two equal parts
1	2	3	4

combination of 2 + 3	2 + 4	3 + 4	2 + 3 + 4	divided and not divisible	other divisions
5	6	7	8	9	0

2a. Other divisions of the tunes:

division only into three	combination of 1 + 2 (from question 2)	combination of 1 + 3 (from question 2)	combination of 1 + 4 (from question 2)
1	2	3	4

combination of 1 1 (from question 2)	not clear	none
5	8	9

3. Existence of variations of the tunes:

    a) only for one tune:

minor variations	"creative" variations
1	2

    b) for several of the tunes:

minor variations	"creative" variations	non-existent
3	4	9

* *tune = part of the song which can stand as a self-sufficient entity.*

4. The location of common elements between the tunes:

at the beginning	in the middle	at the end	combination of 1 + 2	2 + 3	1 + 3	1 + 2 + 3
1	2	3	4	5	6	7

5 + 5	no elements in common	the melody consists of one tune only
8	9	0

5. Extent and character of the common elements in the tunes:

a) consists of one motif only:

without change	in variation	1 + appearance at a different "level"	2 + appearance at a different "level"
1	2	3	4

b) consists of more than one motif:

without change	in variation	1 + "level"*	2 + "level"	no elements in common	only one tune exists
5	6	7	8	9	0

6. Location and number of elements in common in the different tunes and in the melody as a whole:

a) the location includes the end of the melody with:

only one common element between two tunes	one common element to three tunes	between more than three tunes	a number of common elements between a number of tunes
1	2	3	4

no elements in common	only one tune exists
9	0

7. Immediate and exact repetition of sections (each section includes a minimum of one tune):

at the beginning	in the middle	at the end	combination of 1 + 2	1 + 3	2 + 3
1	2	3	4	5	6

1 + 2 + 3	no repetition	only one tune exists
7	9	0

8. Repetition, but not immediate:

a) of one section, which is the :

opening section (or a') appearing also in the middle	opening section (or a') appearing also at the end	middle section appearing again in the middle	middle section appearing again at the end
1	2	3	4

b) of a number of sections:

combination of 1 + 3	1 + 4	2 + 3	no repetition	only one tune exists
5	6	7	9	0

* level = transposition, real or tonal.

Appendix I

The musical parameters

A. Intervals

9. Type of 3rds:

one ascend- ing only	one descend- ing only	one ascending and descending	several ascend- ing only
1	2	3	4

several descend- ing only	several 3rds, ascending and descending	none
5	6	9

10. Location of 3rds:

opening	internal	between phrases	combination of 1 + 2	1 + 3	2 + 3
1	2	3	4	5	6

1 + 2 + 3	also at the end	no place
7	8	9

11. Type of 4ths:

one ascend- ing only	one descend- ing only	one ascending and descending	several ascend- ing only
1	2	3	4

several descend- ing only	several, ascending and descending	none
5	6	9

12. Location of 4ths:

opening	internal	between phrases	combination of 1 + 2	1 + 3	2 + 3
1	2	3	4	5	6

1 + 2 + 3	also at the end	no place
7	8	9

13. Ascending 5ths - location:

opening	internal	between phrases	combination of 1 + 2	1 + 3	2 + 3
1	2	3	4	5	6

1 + 2 + 3	also at the end	no place
7	8	9

14. Special cases of intervals:

descending 5th in the opening	internal descending 5th	descending 5th between phrases	ascending 6th and 7th
1	2	3	4

descending 6th and 7th	ascending and descending octave	combination of different 5ths	other combinations	none
5	6	7	8	9

B. *Pivotal notes (P.N.) and relationship of other notes to P.N.*

15. Number of tones in the melody:

one	two	two ⊥	three	three ⊥	four	five	not clear
1	2	3	4	5	6	7	9

16. Ambitus between the two main pivotal notes:

unison	2nd	3rd	4th	5th	not clearly defined
1	2	3	4	5	9

17. The general ambitus of the pivotal notes:

unison	2nd	3rd	4th	5th	6th	7th and octave
1	2	3	4	5	6	7

more than an octave	not clear
8	9

18. Number of recitation tones:

one	two . . .	none
1	2	9

19. Location of recitation tones in relation to P.N. - in the case of one recitation tone only:

identical to P.N.	a 2nd above or below the P.N.	at any other interval from the P.N.	no recitation tones
1	2	3	9

20. Location of recitation tones in relation to P.N. - in the case of two recitation tones:

one of them identical to P.N.	removed one 2nd and one 3rd from P.N.	other intervals	combination of 1 + 2
1	2	3	4

2 + 3	1 + 3	1 + 2 + 3	not clear	none
5	6	7	8	9

21. Internal cadential tones:

identical to P.N.	a 2nd from P.N.	at any other interval	identical + 2nd	identical + other interval
1	2	3	4	5

2nd + interval	identical + 2nd + interval	not clear	no internal cadential tones
6	7	8	9

22. Finalis:

identical to the lowest P.N.	identical to the highest P.N.	identical to another P.N.	adjacent below the lowest P.N.
1	2	3	4

adjacent above the highest P.N.	other cases	not clear
5	6	9

C. *Musical motifs*

C[1]. *Number of important motifs*

23. Total number of different motifs in the melody:

one	two	three	four	up to four, not clear	up to seven
1	2	3	4	5	6

up to ten	up to fifteen	more	not clear
7	8	9	0

24. The number of different 2nds in motifs built on dichords:

    a) one motif for each second:

one 2nd	two	three	four or more
1	2	3	4

    b) more than one motif for each 2nd:

one 2nd	two	three	four	none	not clear
5	6	3	8	9	0

25. The number of different 3rds in motifs built on trichords:

    a) one motif for each 3rd:

one 3rd	two	three	four
1	2	3	4

    b) more than one motif for each 3rd:

one 3rd	two	three	four	none	not clear
5	6	7	8	9	0

26. The number of different 4ths in motifs built on tetrachords:

    a) one motif for each 4th:

one 4th	two	three	four
1	2	3	4

    b) more than one motif for each 4th:

one 4th	two	three	four	none	not clear
5	6	7	8	9	0

27. The number of motifs built on pentachords:

one of an unbroken 5th	two of an unbroken 5th	more than two of an unbroken 5th	one of a broken 5th
1	2	3	4

two of a broken 5th	more than two of a broken 5th	combination of 1 + 4	other combinations	none
5	6	7m	8	9

c^2. *Extent of occurrence of sequences of motifs built of different intervals*

28/29. Immediate sequences:

| few motifs built of 2nds 01 | many built of 2nds 02 | few built of 3rds 03 | many built of 3rds 04 | few built of 4ths 05 |

| many built of 4ths 06 | built of 5ths 07 | built of combination of 2nd and 3rd 08 | built of 2nd and 4th 09 | built of 2nd and 5th 10 |

| built of 3rd and 4th 11 | built of 3rd and 5th 12 | built of 4th and 5th 13 | built of 2nd, 3rd and 4th 14 |

| other combinations and 5th 15 | no sequence 00 |

30. Other sequence:

    a) Shift of a 2nd:

| motif built of a 3rd or a 2nd 1 | built of a 4th 2 | built of a 5th 3 | built of combinations 4 |

    b) shift of an interval other than a 2nd:

| motif built of a 3rd or a 2nd 5 | built of a 4th 6 | built of a 5th 7 | built of combinations 8 | combination of a) + b) 9 |

| no sequence 0 |

c^3. *Connections between motifs*

32. Partially combined:

| little 1 | frequent 2 | predominant 3 | not clear 4 | none 9 |

33. Strongly combined:

| little 1 | frequent 2 | predominant 3 | not clear 4 | none 9 |

c^4. *Other information*

34. Motifs built on prime

    a) without sequence:

        consists of two repeated notes:

| appears on one note only 1 | appears on more than one note 2 |

        consists of three notes or more:

| appears on one note only 3 | appears on more than one note 4 |

b) with sequence:

consists of two repeated notes	consists of three or more notes
5	6

c) combinations:

1 + 3	motifs without sequence consisting of two or more repeated notes appearing on different notes	combination of a) + b)	none
7	8	9	0

35. Ambitus:

2nd	3rd	4th	5th	6th	7th	octave and 9th	10th
1	2	3	4	5	6	7	8

more than a 10th
9

36. Other data concerning the cadential motif (in addition to information from the first category M.S.A.)

   a) not including intervals other than the 2nd:

not including another direction	including another direction
1	2

   b) including other intervals:

not including another direction	including another direction
3	4

37. Other data concerning the opening motif:
   same breakdown as in 36.

38. Appearance of the triad:
   a) without the octave:

      in pure form:

only in the middle	also at the beginning or at the end
1	2

      with auxiliary notes:

only in the middle	also at the beginning or at the end
3	4

   b) with the octave:

      in pure form:

only in the middle	also at the beginning or at the end
5	6

      with auxiliary notes:

only in the middle	also at the beginning or at the end	none
7	8	9

D.   *Time factors: tempo, meter, rhythmic patterns, melismata, etc.*

39. Number of measure

    one   two   three   . . .
     1   2   3

40. Deviation from even symmetry in the number of measures:

    a) deviation to 3+3 or 6+6 or 2+4 or 2+4+2:

        in all the melody   in part of the melody   exceptional
               1   2   3

    b) other deviations:

        in all the melody   in part of the melody   exceptional
               4   5   6

    c) combinations of a) and b)   none
               7   9

41. Meter

                                                                    duple +
    duple   triple   compound 6/8   quintuple   other   compound meters
      1   2   3   4   5   6

    duple +
    other   other combinations
      7   8

42. Appearance of upbeat:

    yes   no   yes and no
     1   2   3

43. Minimal number of notes in a measure:

    one   two   three   ...
     1   2   3

44. Maximal number of notes in a measure:

    four   five   six   seven   eight   nine   ten   eleven   twelve
     1   2   3   4   5   6   7   8   9

45. The difference between the maximum and minimum number of notes in a
    measure:

    zero   one   two   three   ...
     0   1   2   3

46. Degree of melismatic quality in percentage
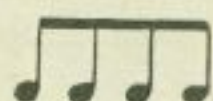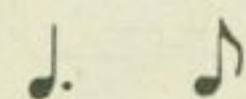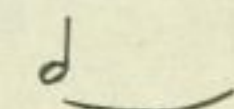
    (number of notes - number of syllables) x 100
                number of syllables

    up to 5%   5-10%   10-15%   15-20%   20-30%   30-50%   50-80%
        1   2   3   4   5   6   7

    80-120%   more
        8   9
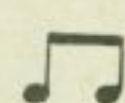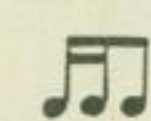
47. Rhythmic patterns

Group A	Group B	Group C

a. (notation)
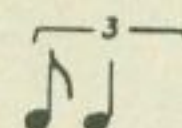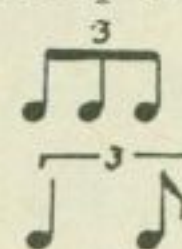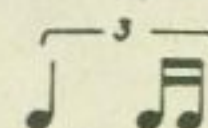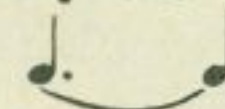
b. break-up of the above

c. long notes

48. Appearance of rythmic patterns from Group B:

only a + b	a + b + c	a + b + c + d	a + b + d	a + b + d + e
1	2	3	4	5

a + b + d + f	a + b + c + f	all	none
6	7	8	9

49. Appearance of rhythmic patterns from Group A:

a) without a prolonged note:

a + b + c	a + b + c + d	a + b + c + e	a + b + c + d + e
1	2	3	4

b) with prolonged note:

a + b + c	a + b + c + d	a + b + c + e	a + b + c + d + e
5	6	7	8

none
9

50. Appearance of triplets (Group C):

only from a	also from b	also from c	also combination of b + c
1	2	3	4

51. Appearance of Syncopation

a little of one type	much of one type	a little of several types	much of several types	none
1	2	3	4	9

52. Long and short notes:

Number of different time values of the notes in the melody:

one	two	three	...
1	2	3	

53. Relation between the duration of the longest to that of the shortest note:

2:1	3:1	4:1	5:1	6:1	8:1	more	others
1	2	3	4	5	6	7	9

54. Location and appearance of long notes (4:1):

only at the end of melody or phrase	only in the middle	also at the beginning	combination of 1 + 2
1	2	3	4

1 + 3 + 4	2 + 3	also or as an opening note 7	none
5	6		9

55. As above (54) when the long note is greater than 4:1.

APPENDIX II

THE SONGS EXAMINED

Examples from the four groups chosen in the study: A - songs in
the major mode; B - Mixolydian; C - Dorian; D - *hedjaz* ("hypo-
harmonic minor").

A. Songs in the major mode (which served as a test group): mostly
of Western origin and anonymous; restricted to tessitura above the
tonic (therefore excluding the many Israeli songs in "hypo-Ionian"
mode).

Awwazah šatah   אוזה שטה

Sîmî yadek   שימי ידך
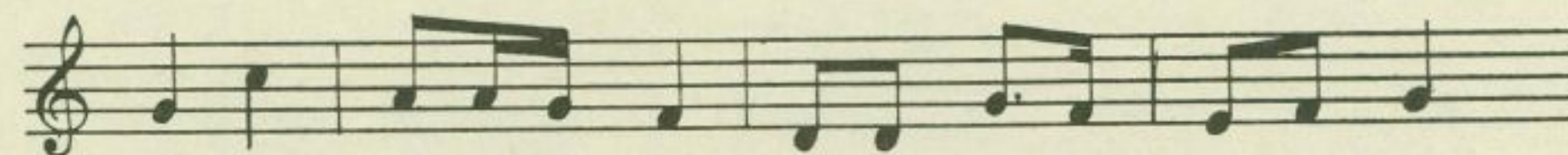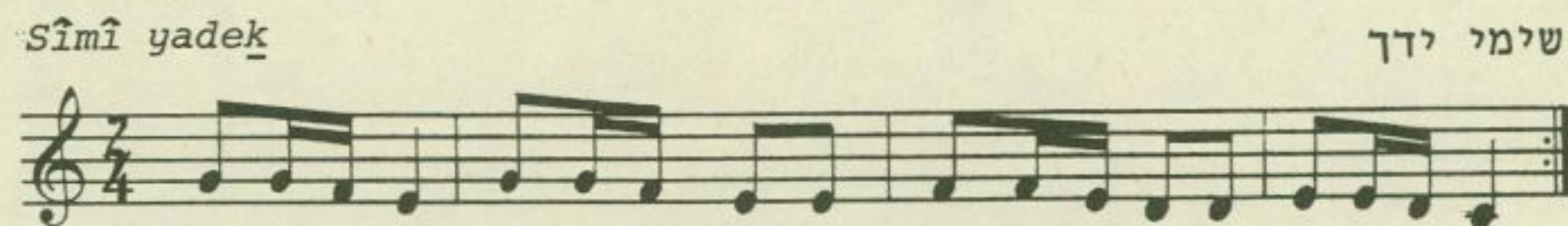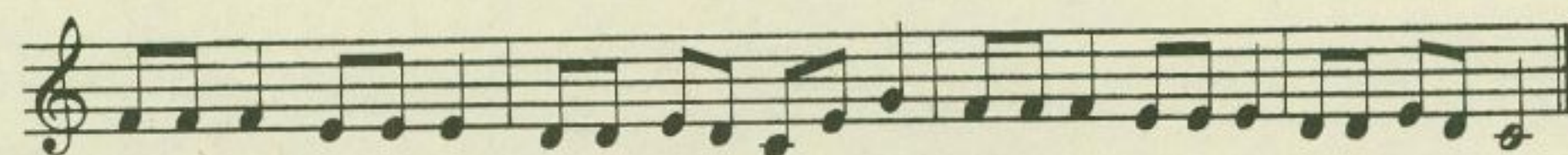
Ḥat š(e)tayim šalôš   חת שתים שלוש
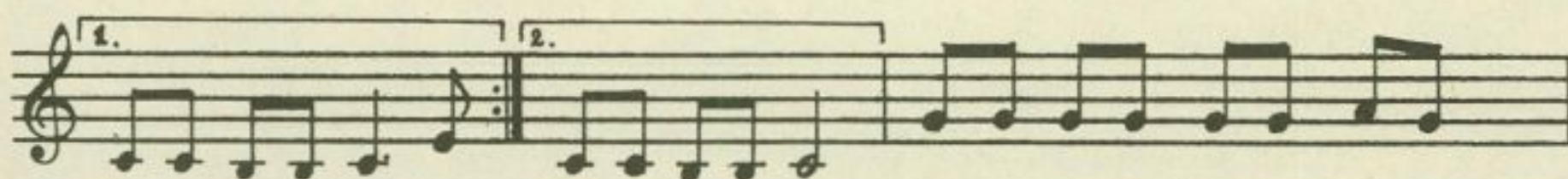
Pirḥê avîv   פרחי אביב
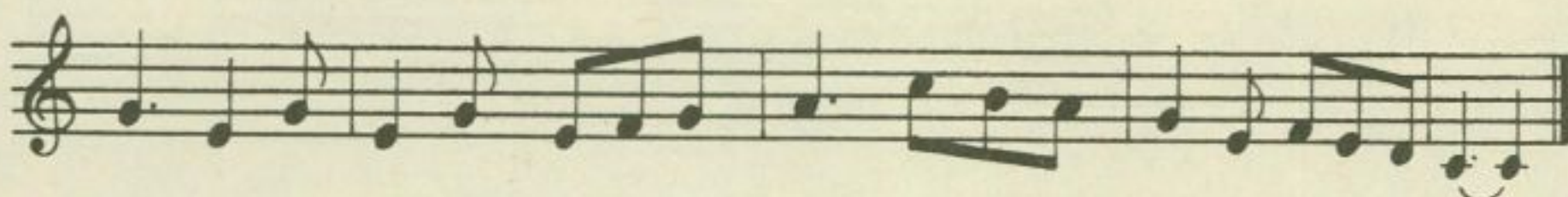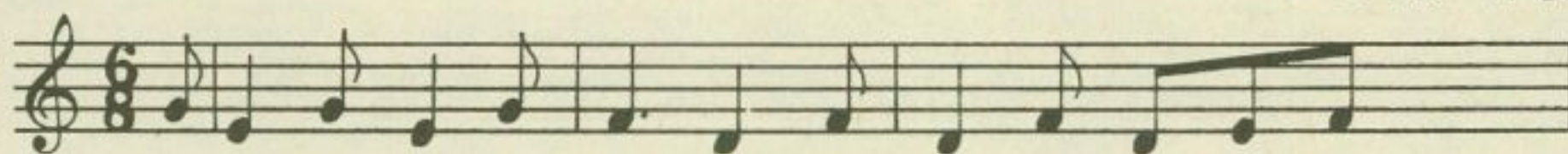
Mî dillel   מי דלל
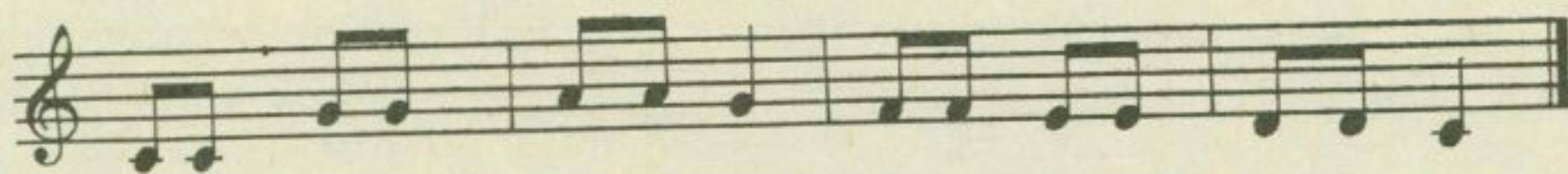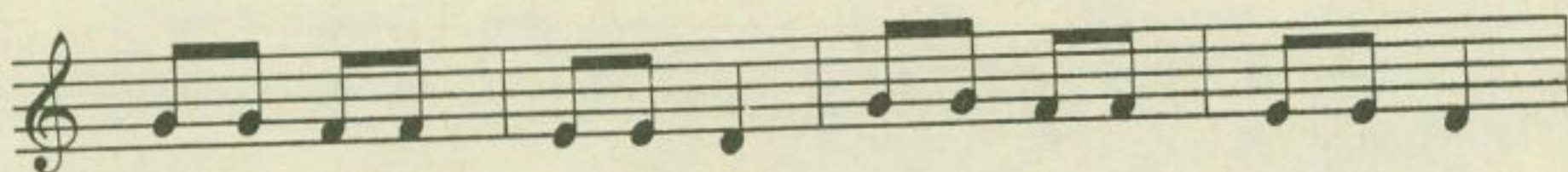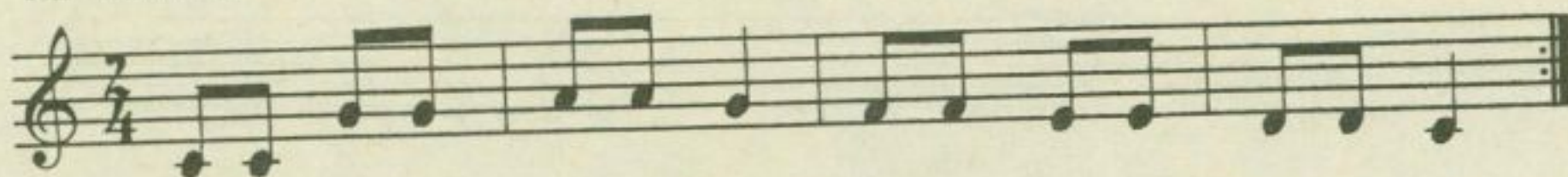
Ha-avîv qarev û-vā   האביב קרב ובא

Hinneh hū bā (Händel) הנה הוא בא (הנדל)

fine

D.C.
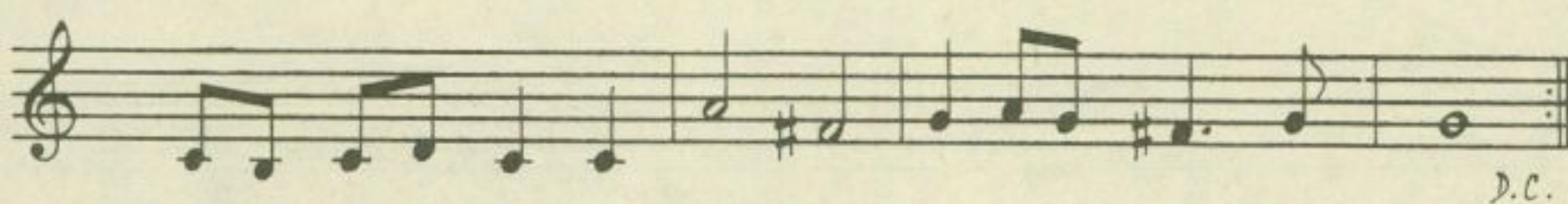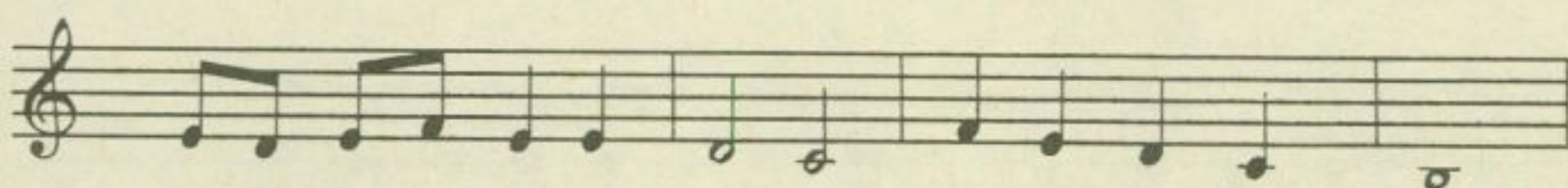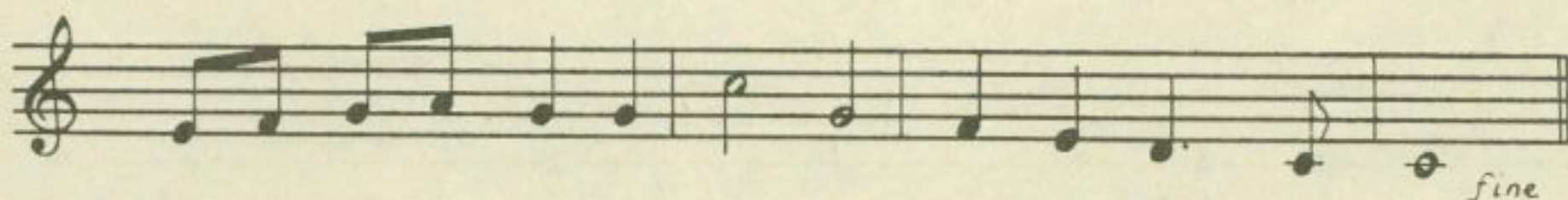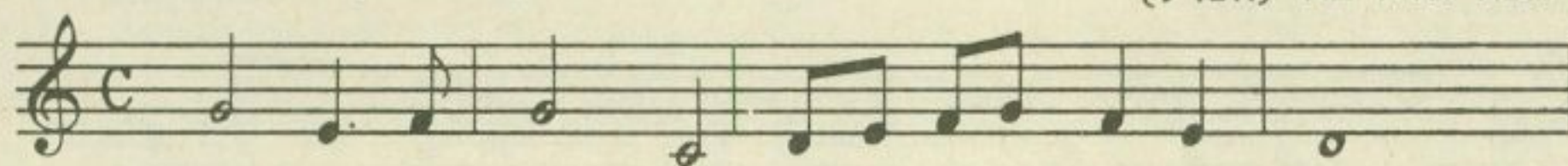
Perôs kenafêka פרוס כנפיך
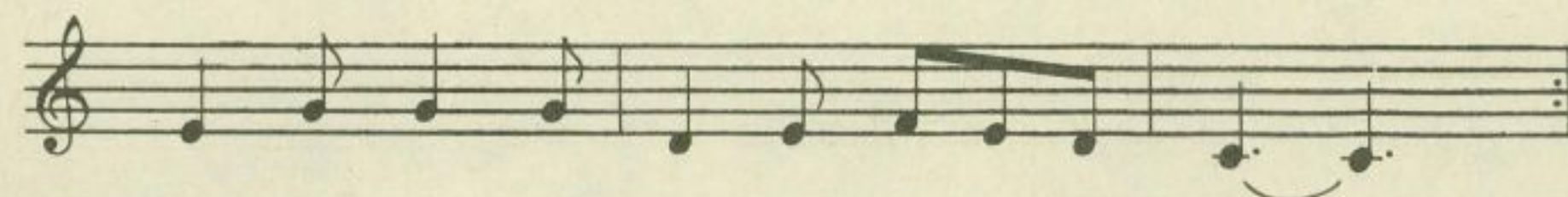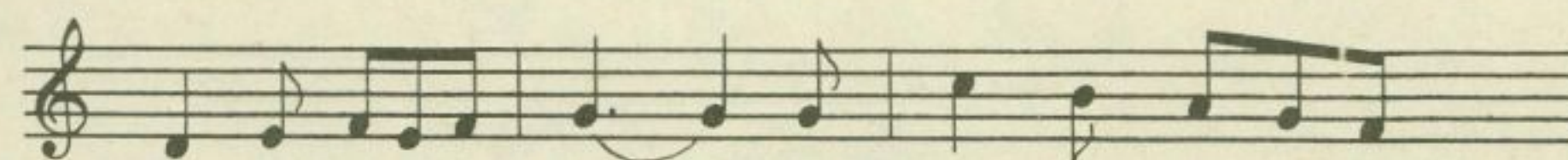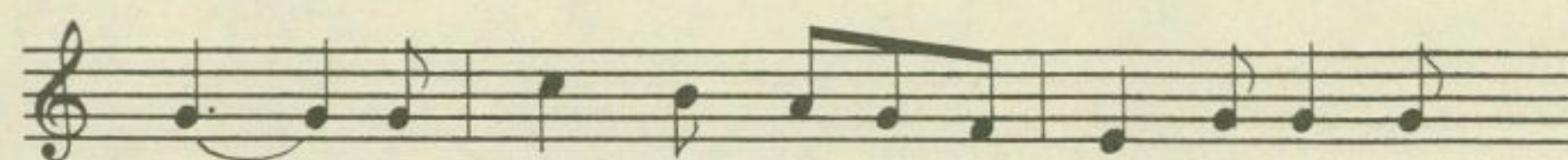
Yônatan haq-qaṭan

יונתן הקטן
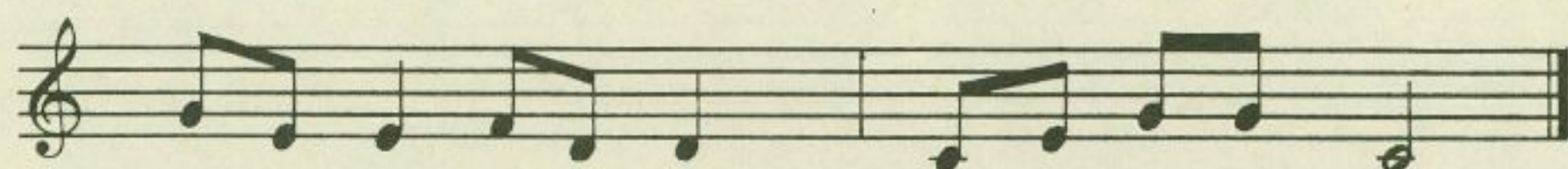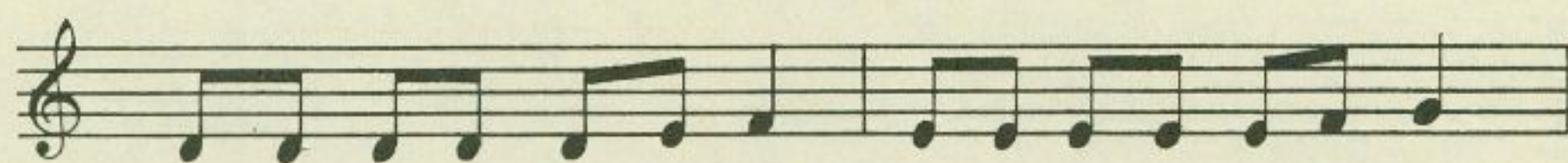
Yoreh yaqar

יורה יקר
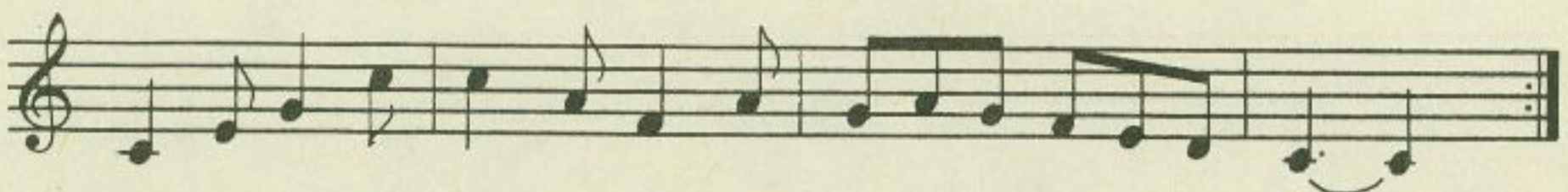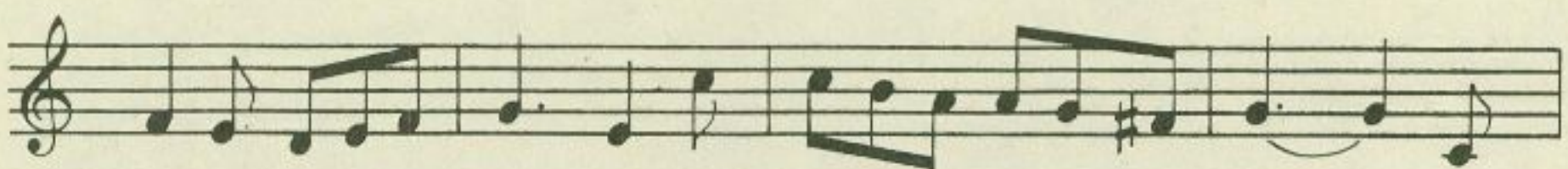
B. Mixolydian songs: indigenous music and text; composer known – a
peculiarity of Israeli folk-song.

Ten katef (M. Ze^cira)
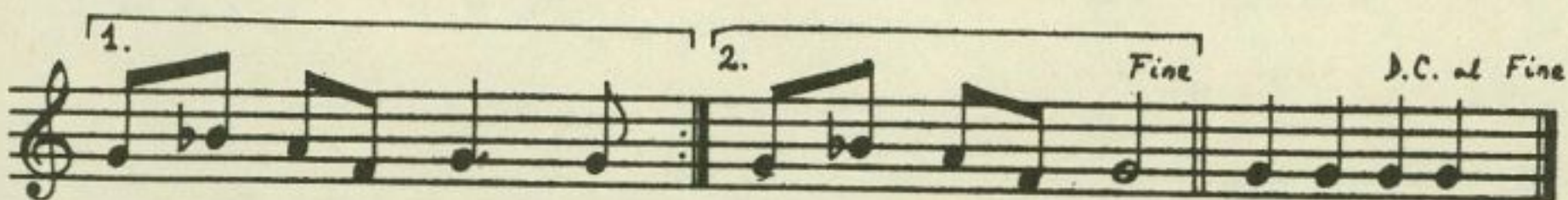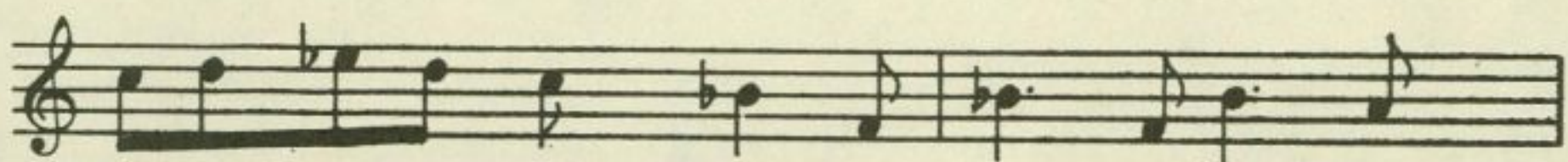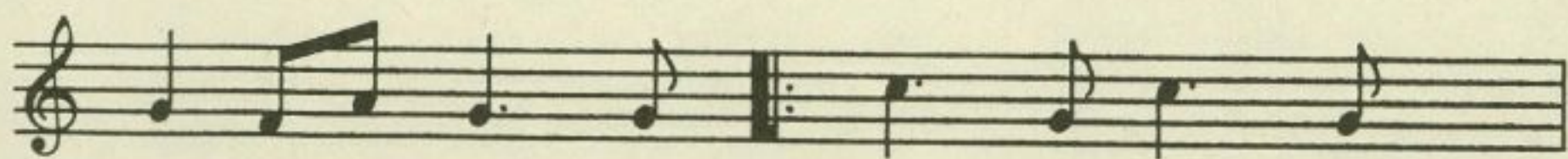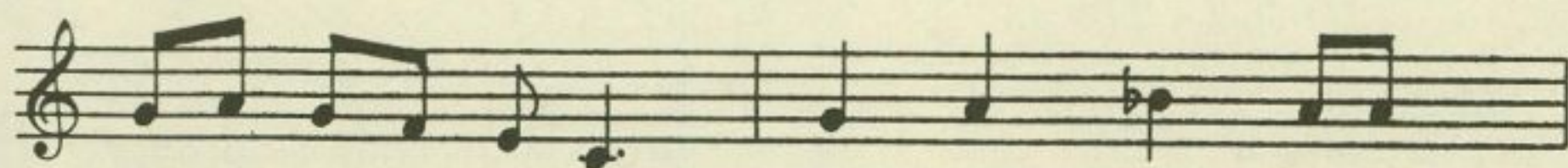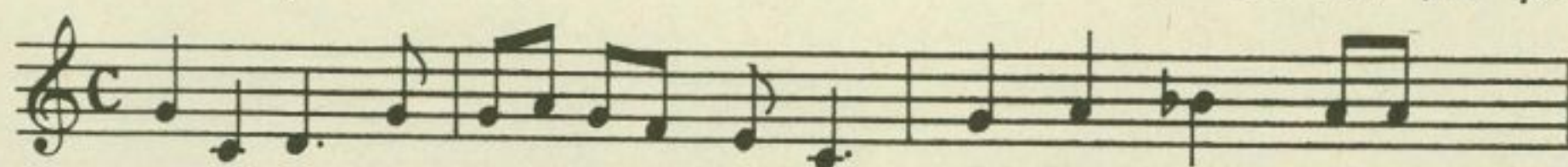
Ḥûlû meḥôl ha-hôrah   חולו מחול ההורה
   (M. Vilenski)   (מ. וילנסקי)
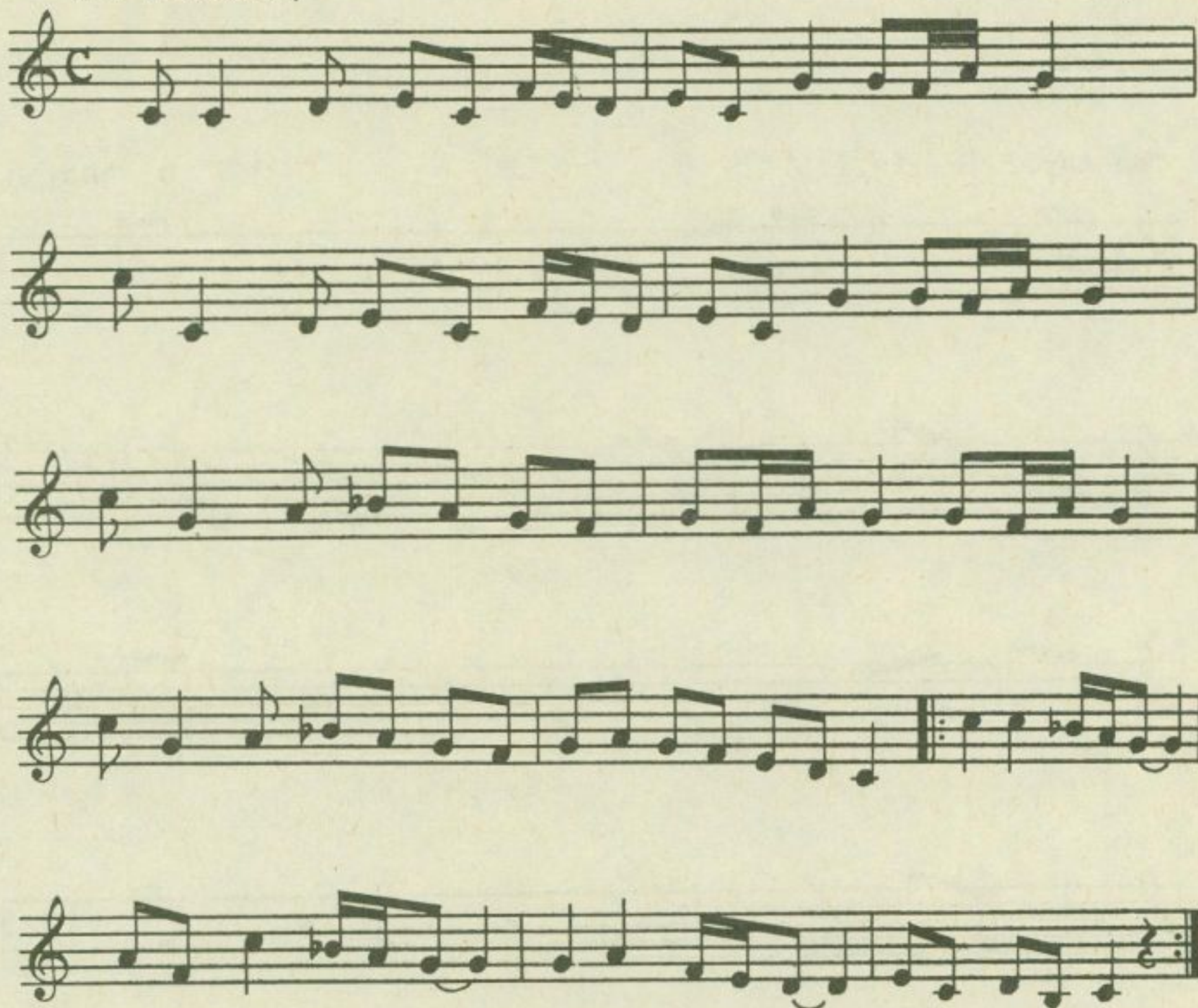
Lanû hak-koaḥ (E. Amiran)   לנו הכח (ע. עמירן)
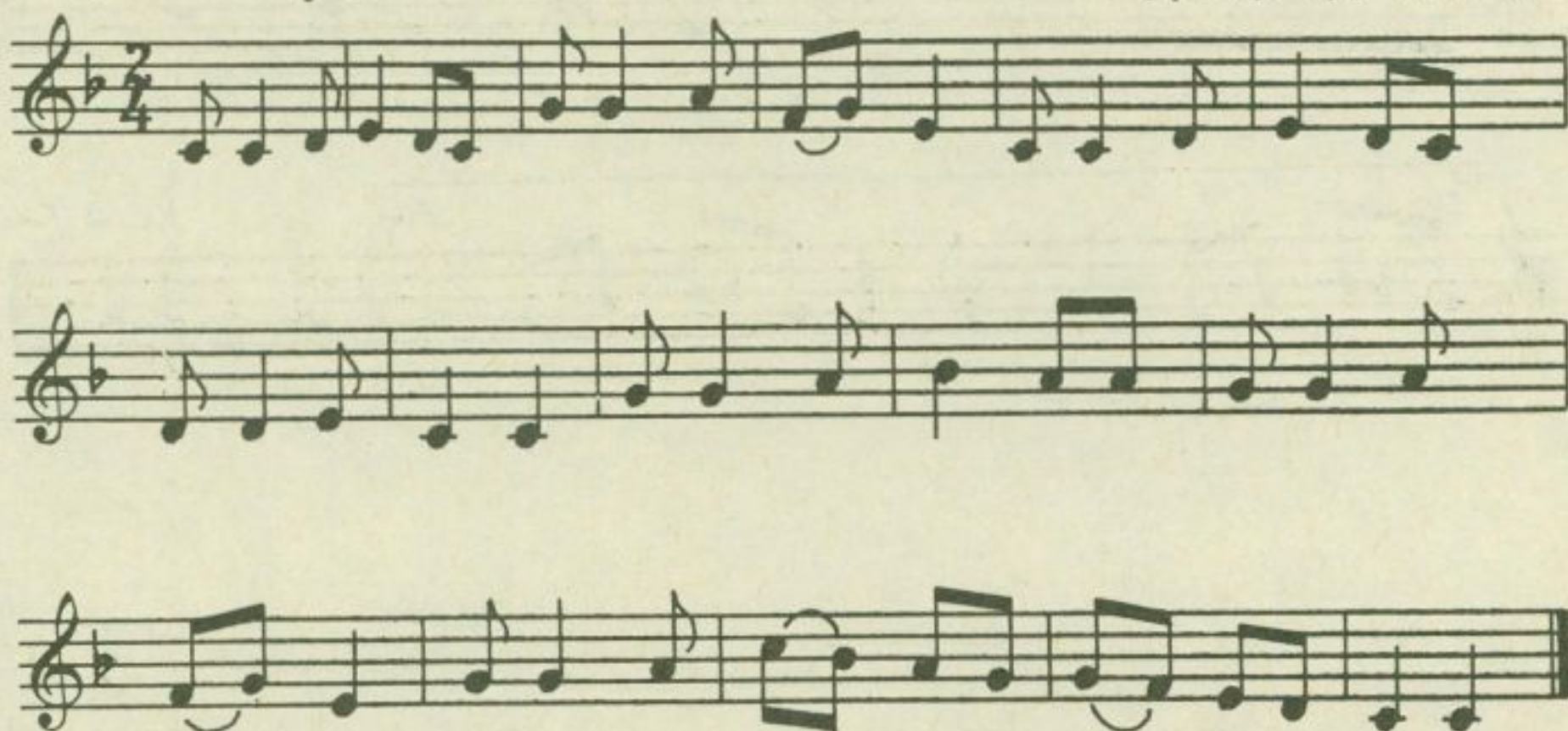
Ken yōvedû (U. Giv'on) כן יאבדו (א. גבעון)
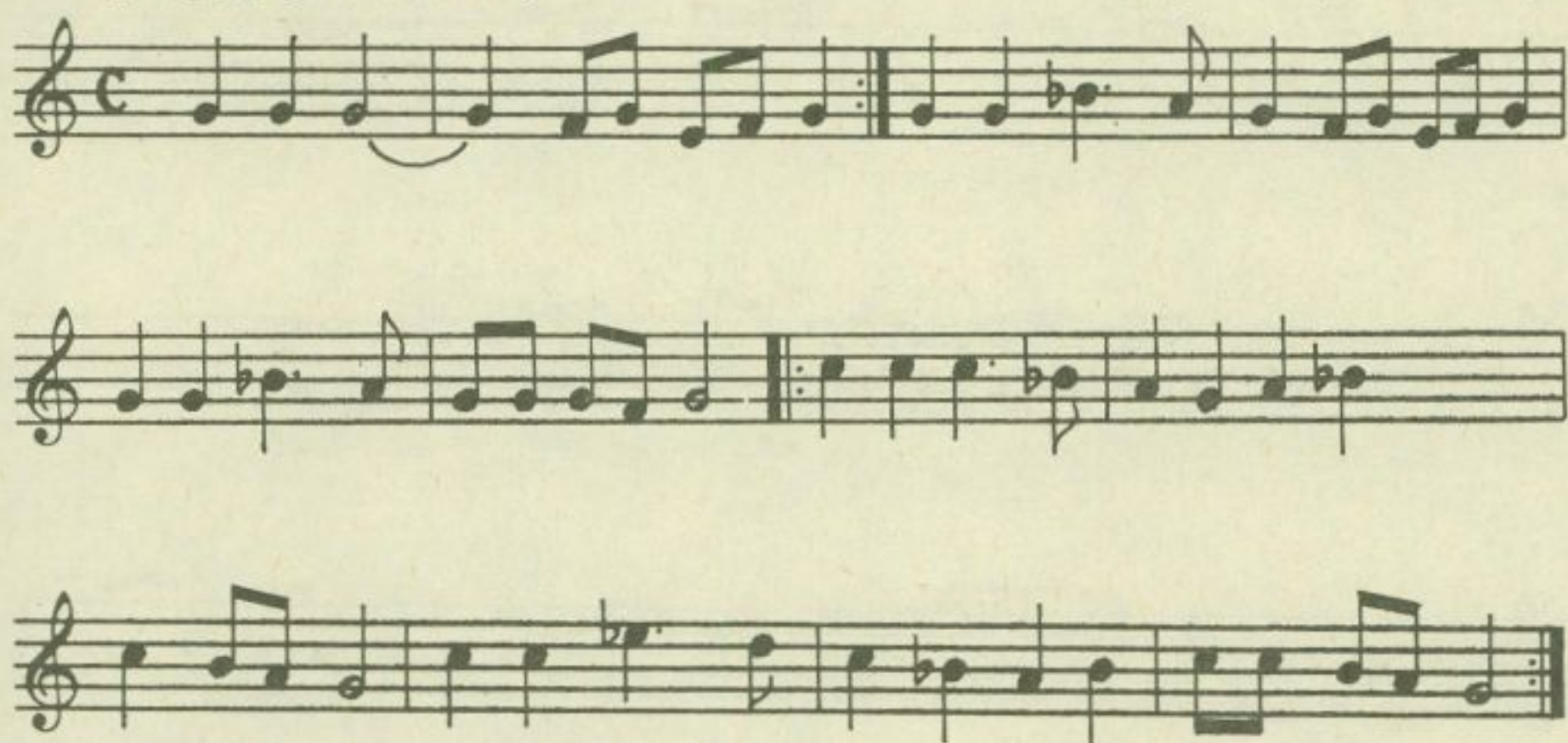
^cAl geva^c ram (Y. Admon) על גבע רם
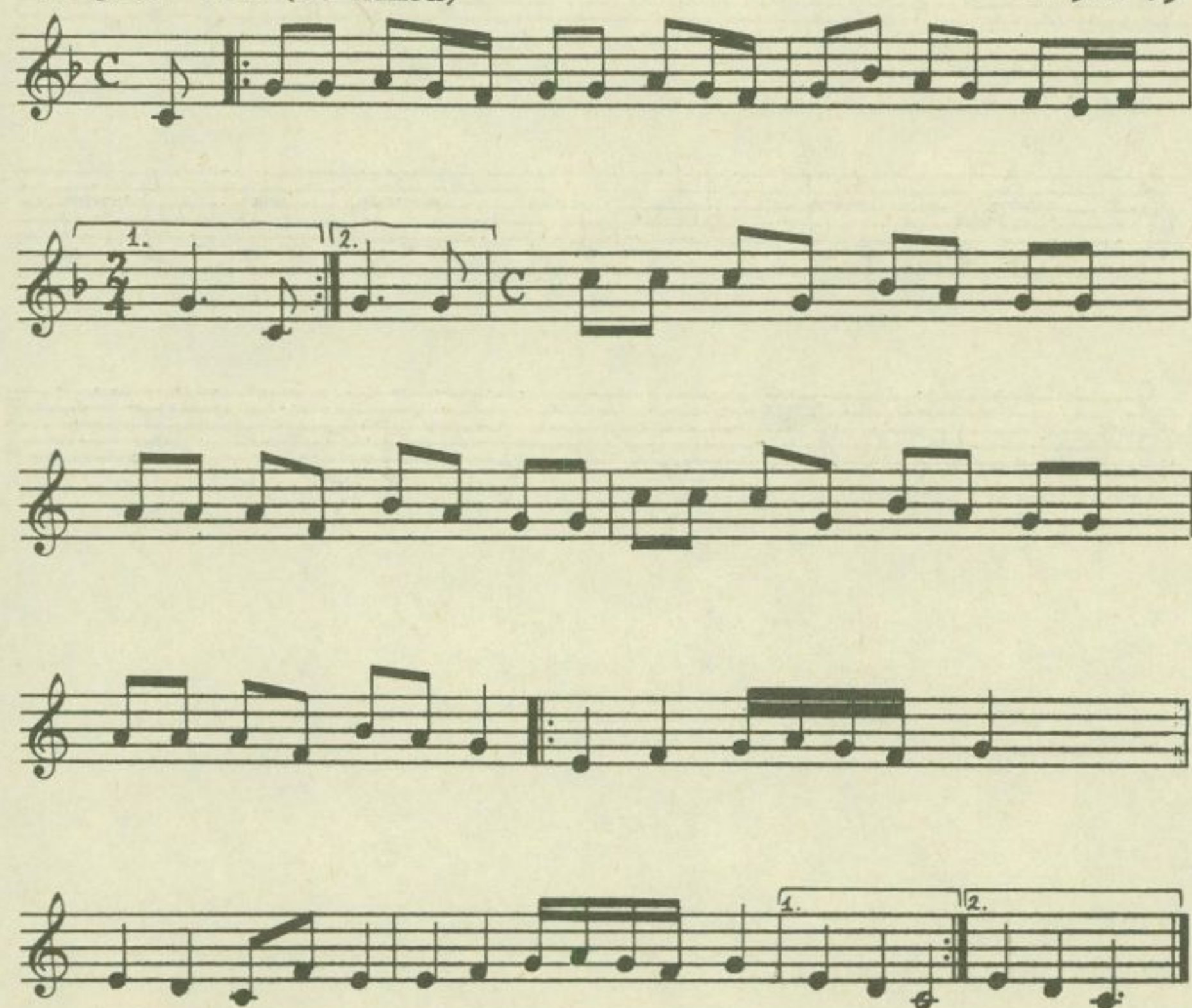
ᶜAdarîm (M. Shelem)   עדרים (מ. שלם)
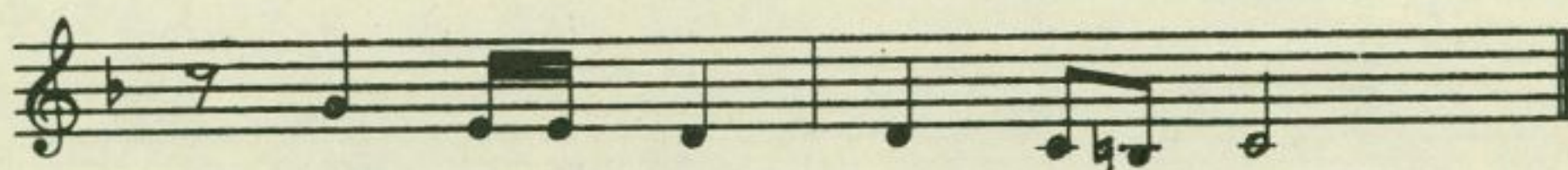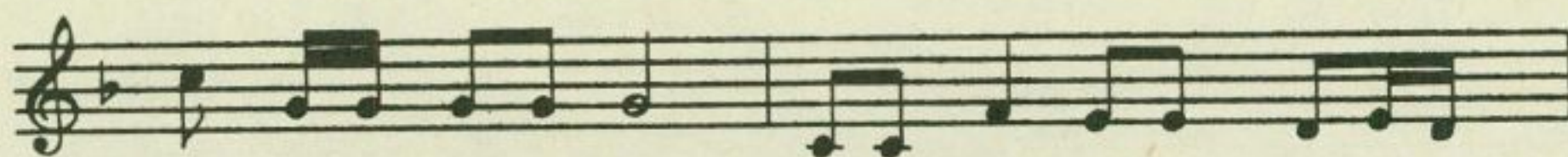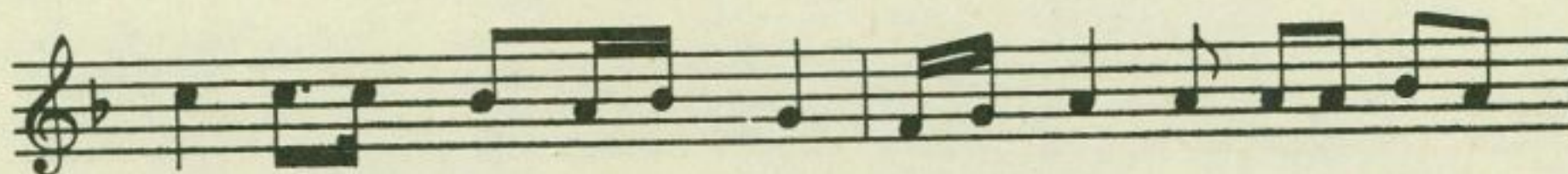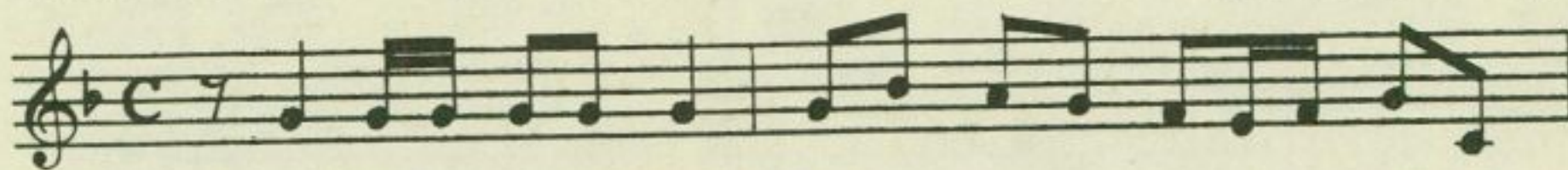
Sîsû we-simhû (M. Shelem)   שישו ושמחו (מ. שלם)
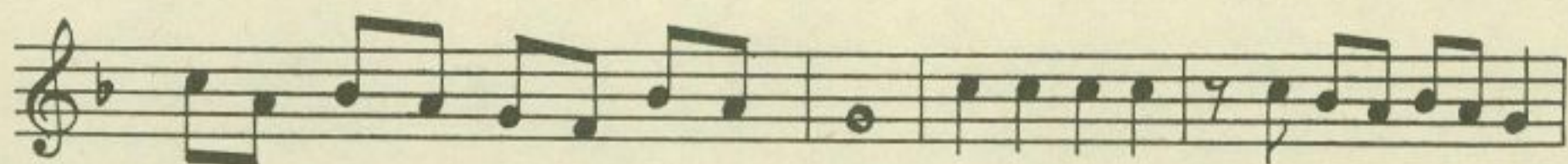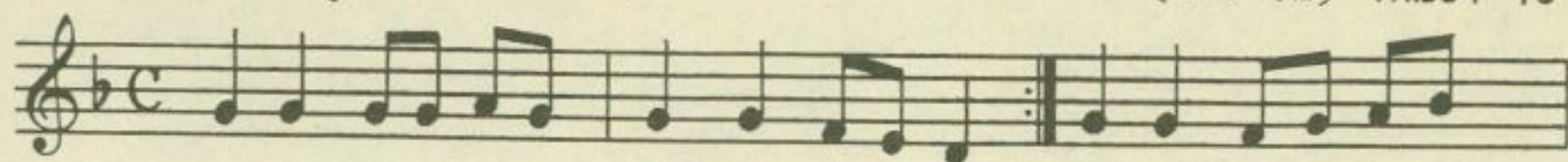
Šîr han-nôded (S. Levi)   שיר הנודד (ש. לוי)
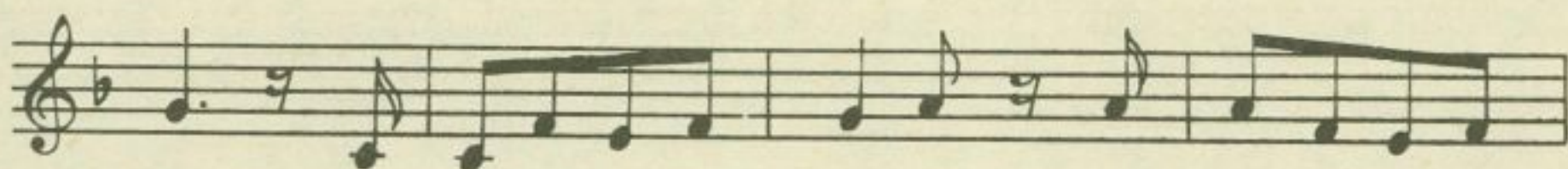
Meḥôl avîv (Y. Hadar)　　　　　　　　　　　　　　מחול אביב (י. הדר)
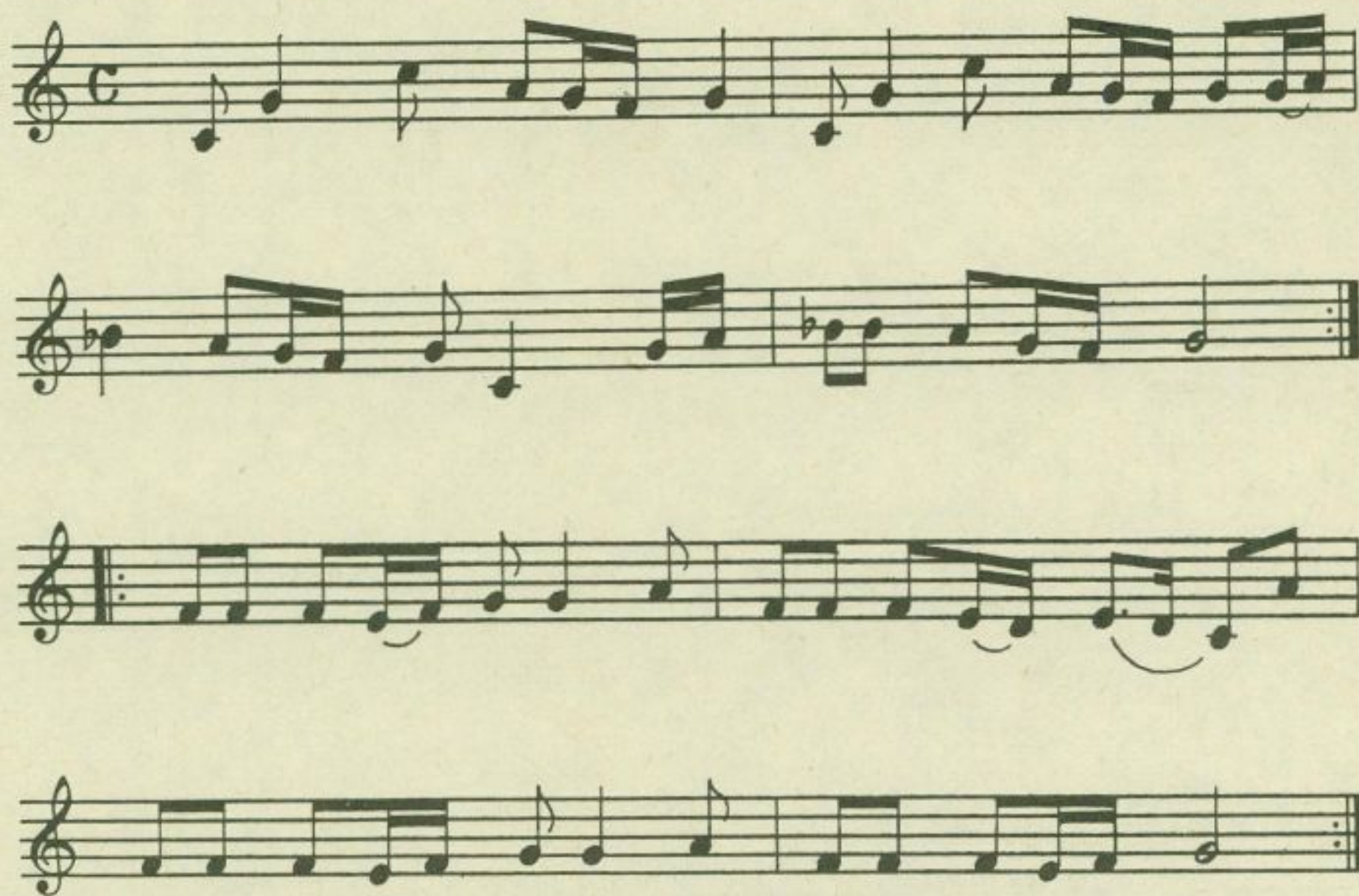
Sallênû (Y. Admon)　　　　　　　　　　　　　　סלינו (י. אדמון)
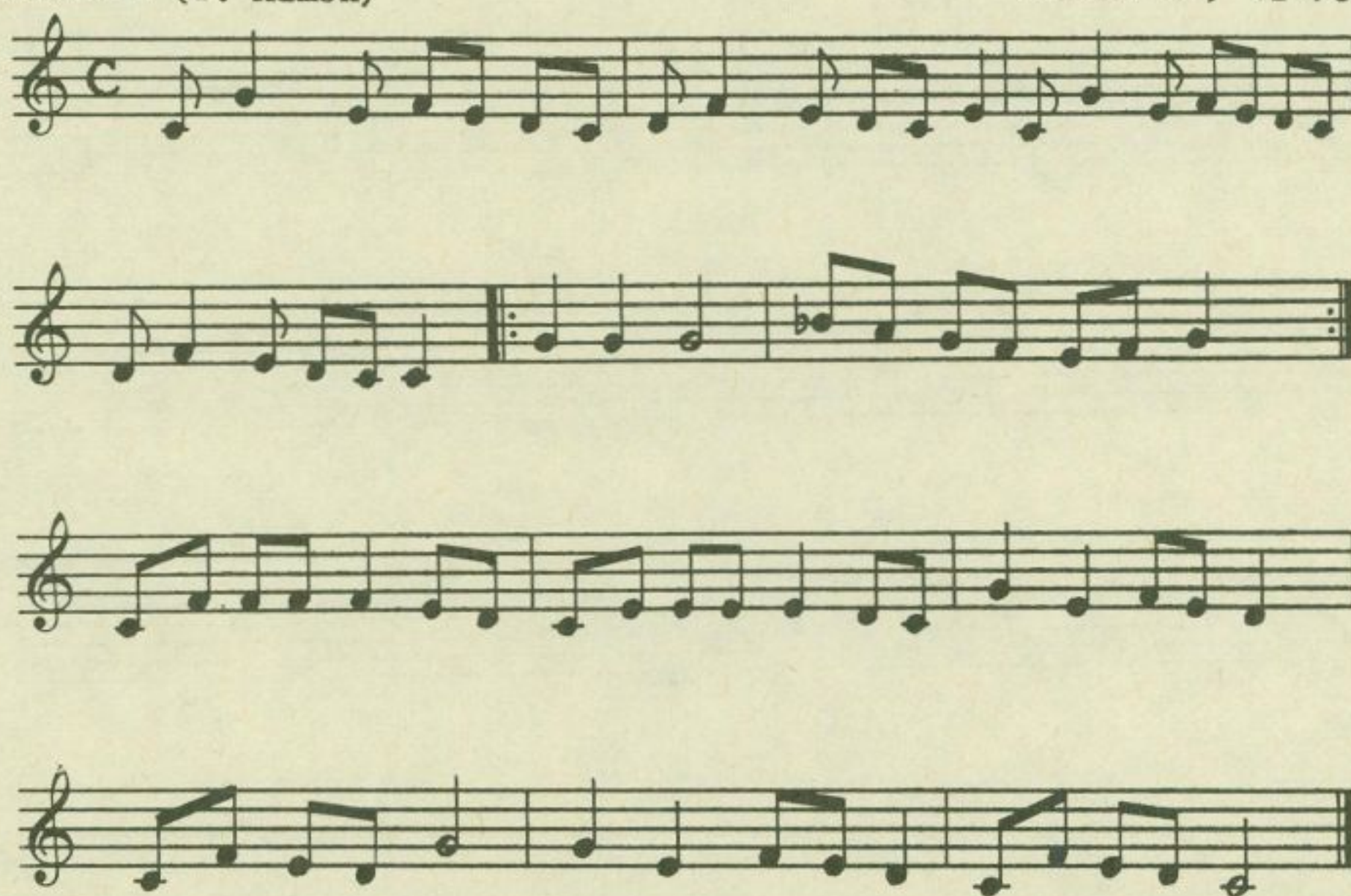
Hallelûyah (A. Ma'ayanî)

הללויה (ע. מעיני)
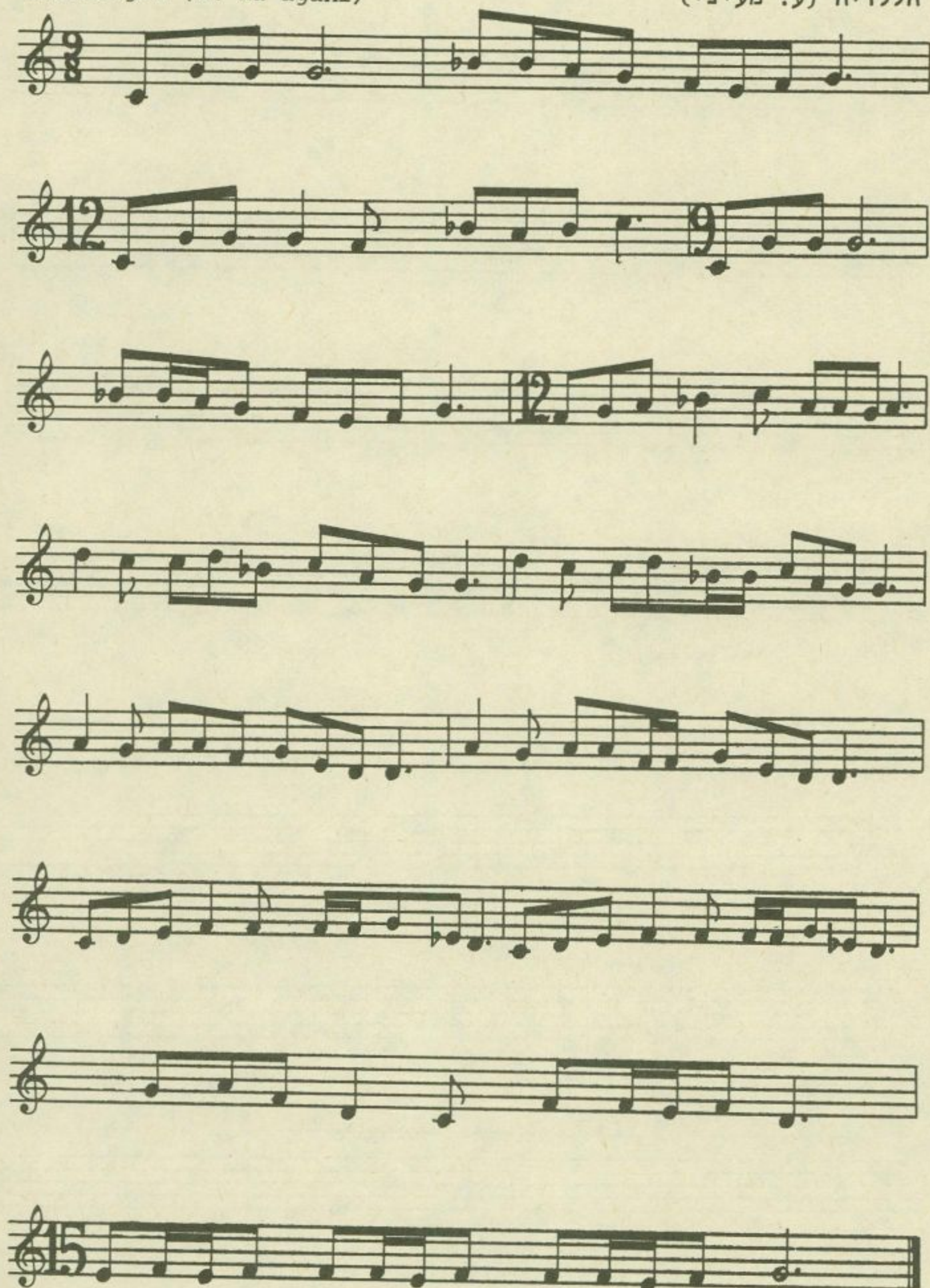
C. Dorian songs: indigenous; composer known.

Qôl dôdî (S. Levi)   קול דודי (ש. לוי)
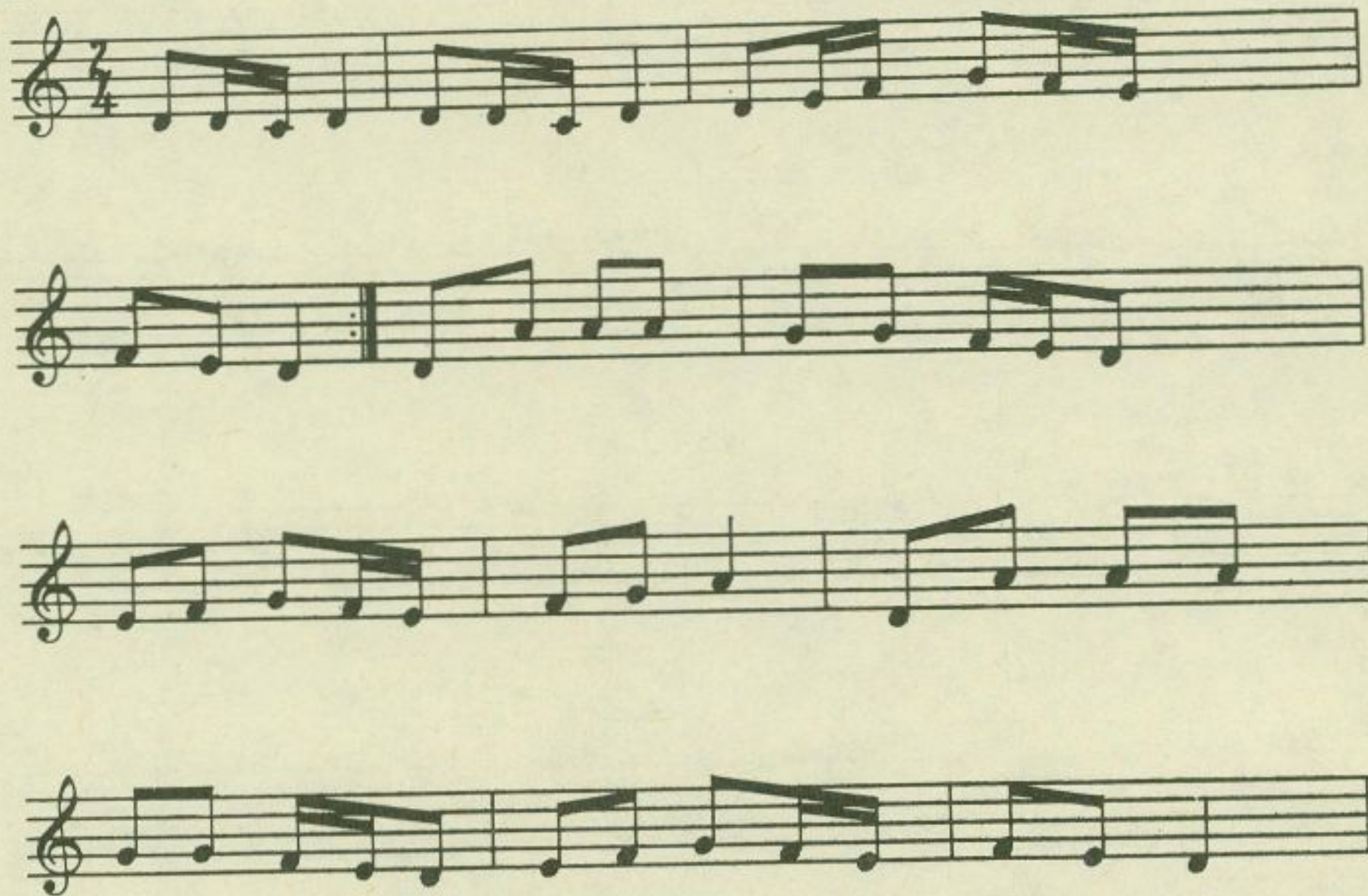
Havû lanû yayin (M. Shelem)   הבו לנו יין (מ. שלם)
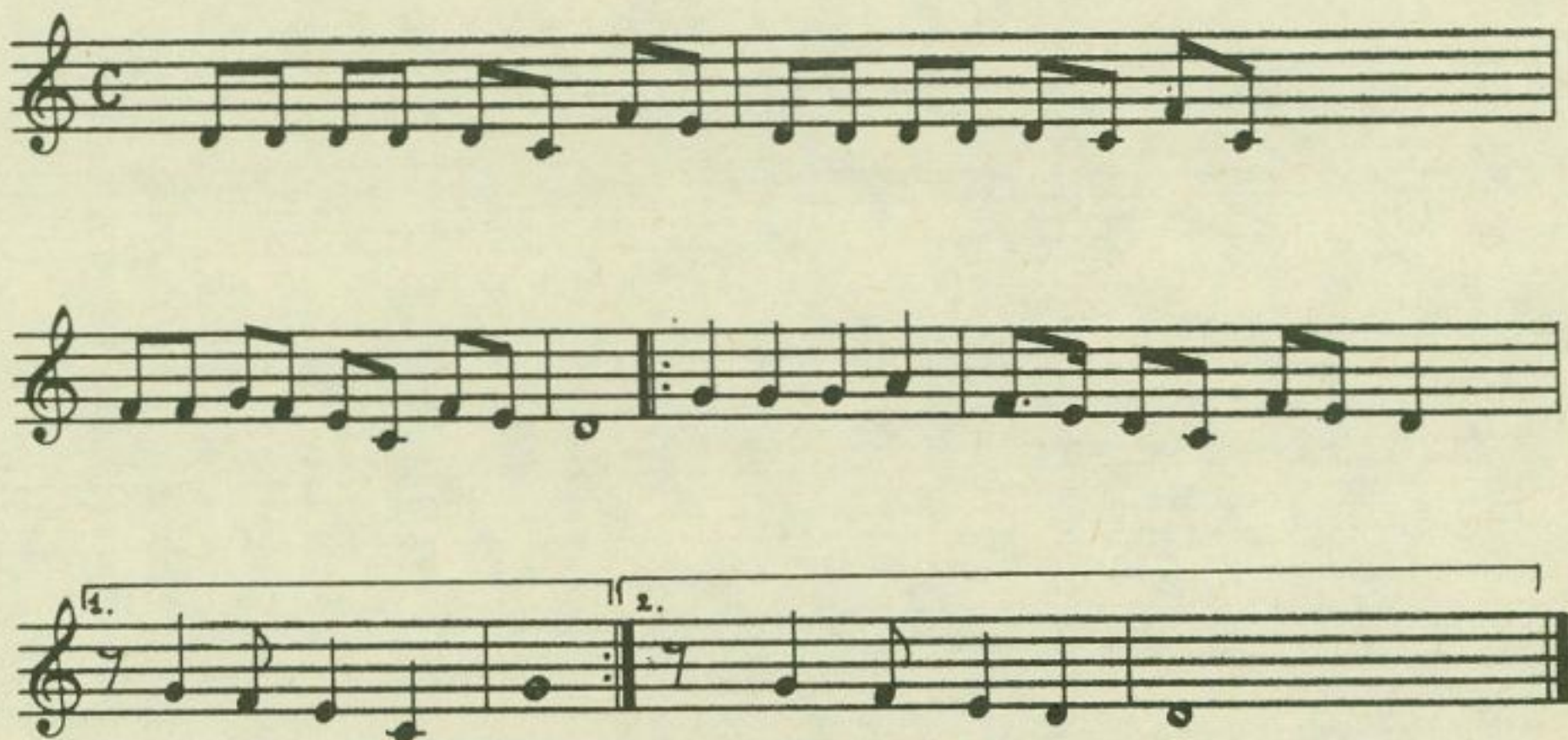
Mî zōt (S. Cerem)   מי זאת (ס. כרם)

fine

D.C.
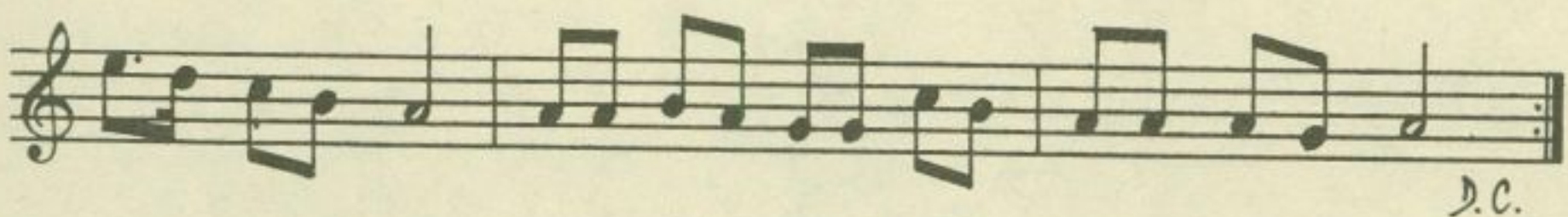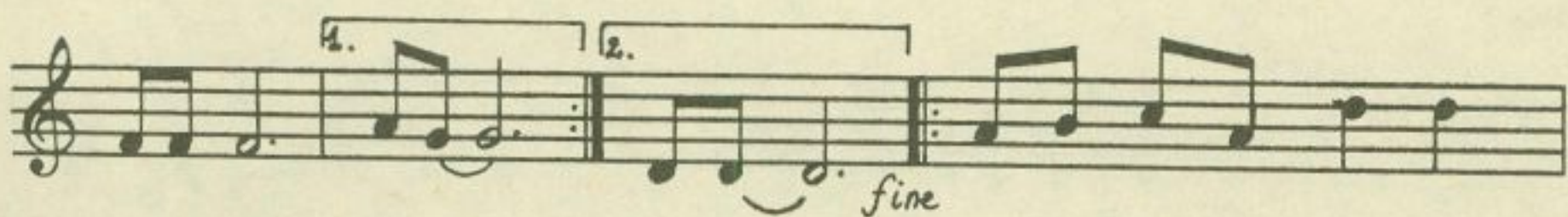
Sammeḥû levav (A. Ne'eman)   שמחו לבב (א. נאמן)

El ginnat egôz (S. Levi)   אל גנת אגוז (ש. לוי)

Debqa dalyah (E. Zamir)   דבקה דליה (ע. זמיר)

D.C.

El ha-rahat (S. Levi)   אל הרהט (ש. לוי)
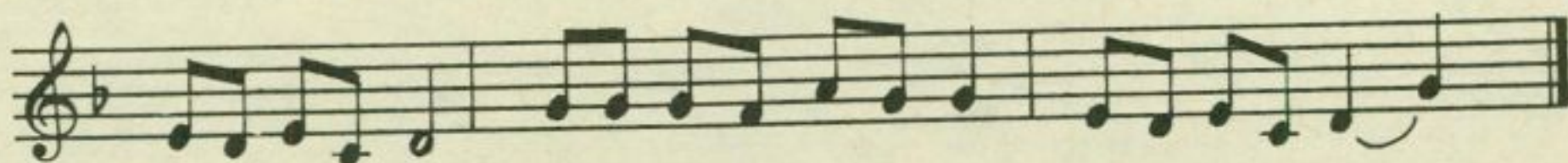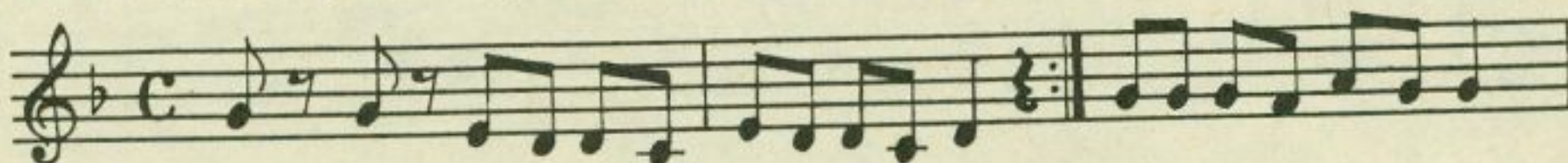
Hag (E. Zamir)   חג (ע. זמיר)

Ba'ah **menûḥah lay-yage**^Ca
(D. Samburski)

באה מנוחה ליגע
(ד. סמבורסקי)
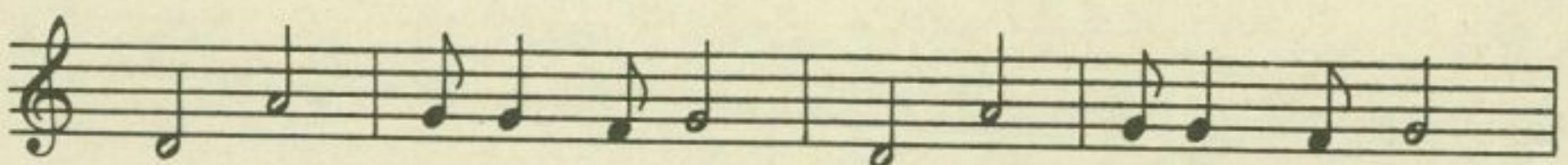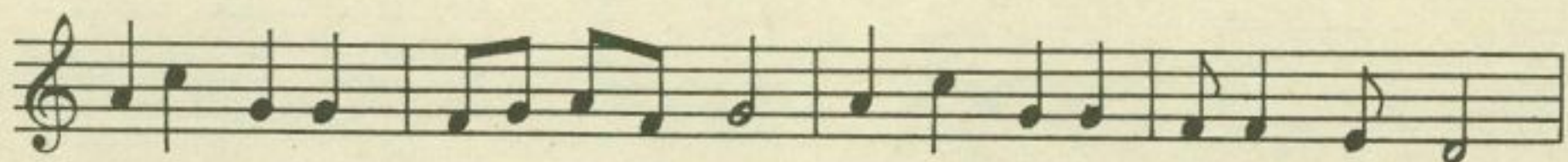
Dôdî lî (N. Chen)

דודי לי (נ. חן)
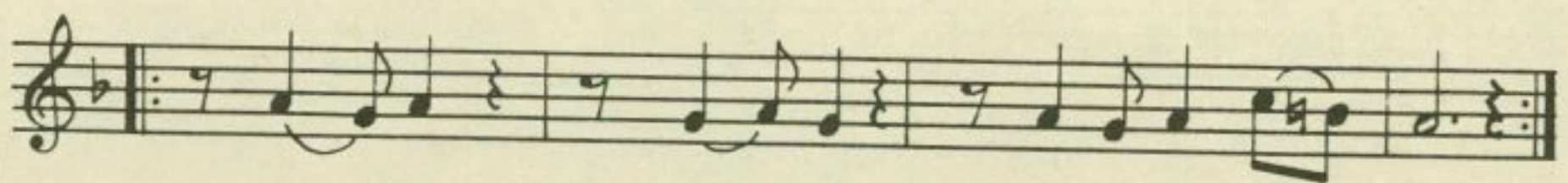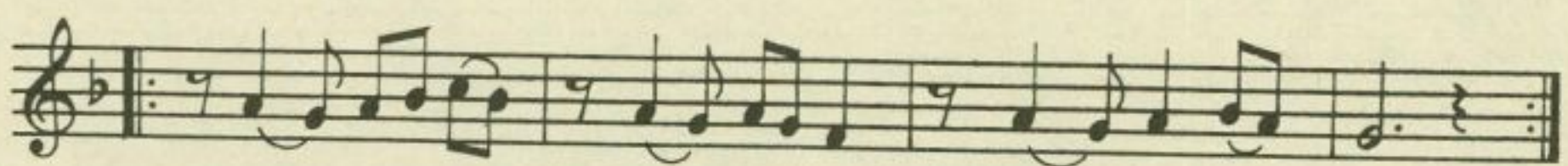
Be'er bas-sadeh (E. Zamir)   באר בשדה (ע. זמיר)

Ẕelîl zôgîm (E. Zamir)   צליל זוגים (ע. זמיר)
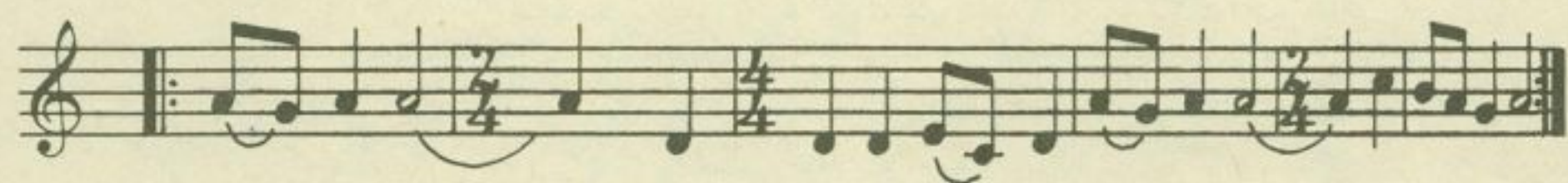
D. Songs in *hedjaz*: Mostly anonymous; partly of European and partly of Near Eastern origin; transformed and adapted to Israeli taste.

Havah nagîlah
(Hassidic tune)

הבה נגילה
(נעימה חסידית)
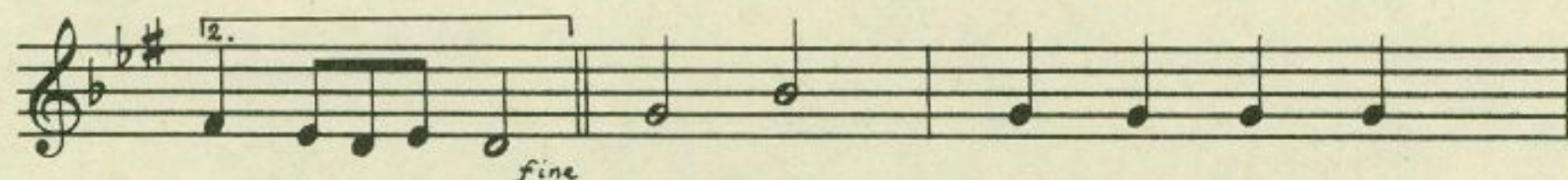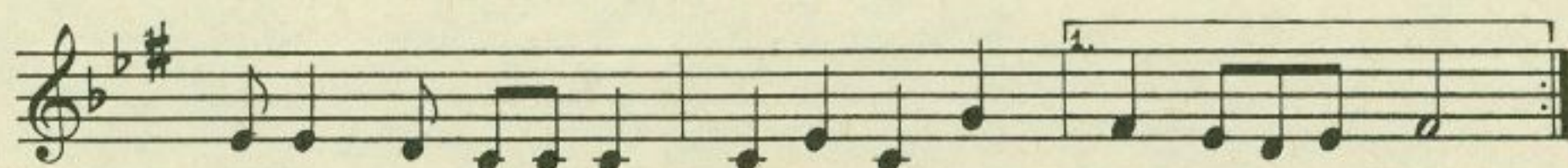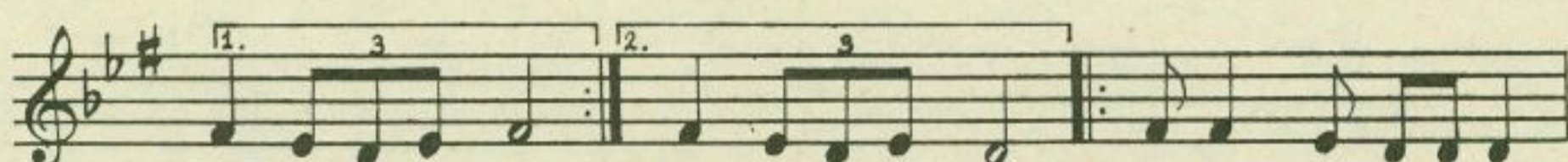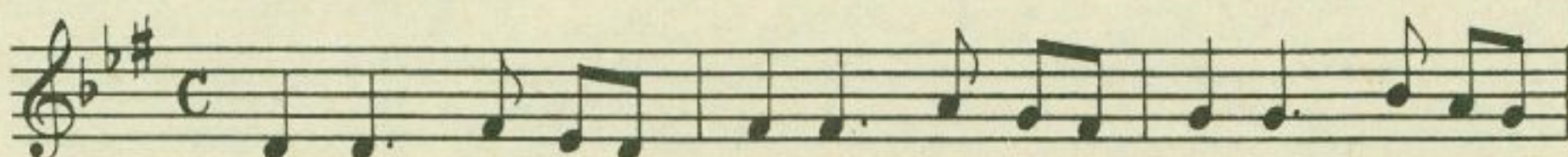
ᶜEt dôdîm kallah   עת דודים כלה (מפי משה יצחק)
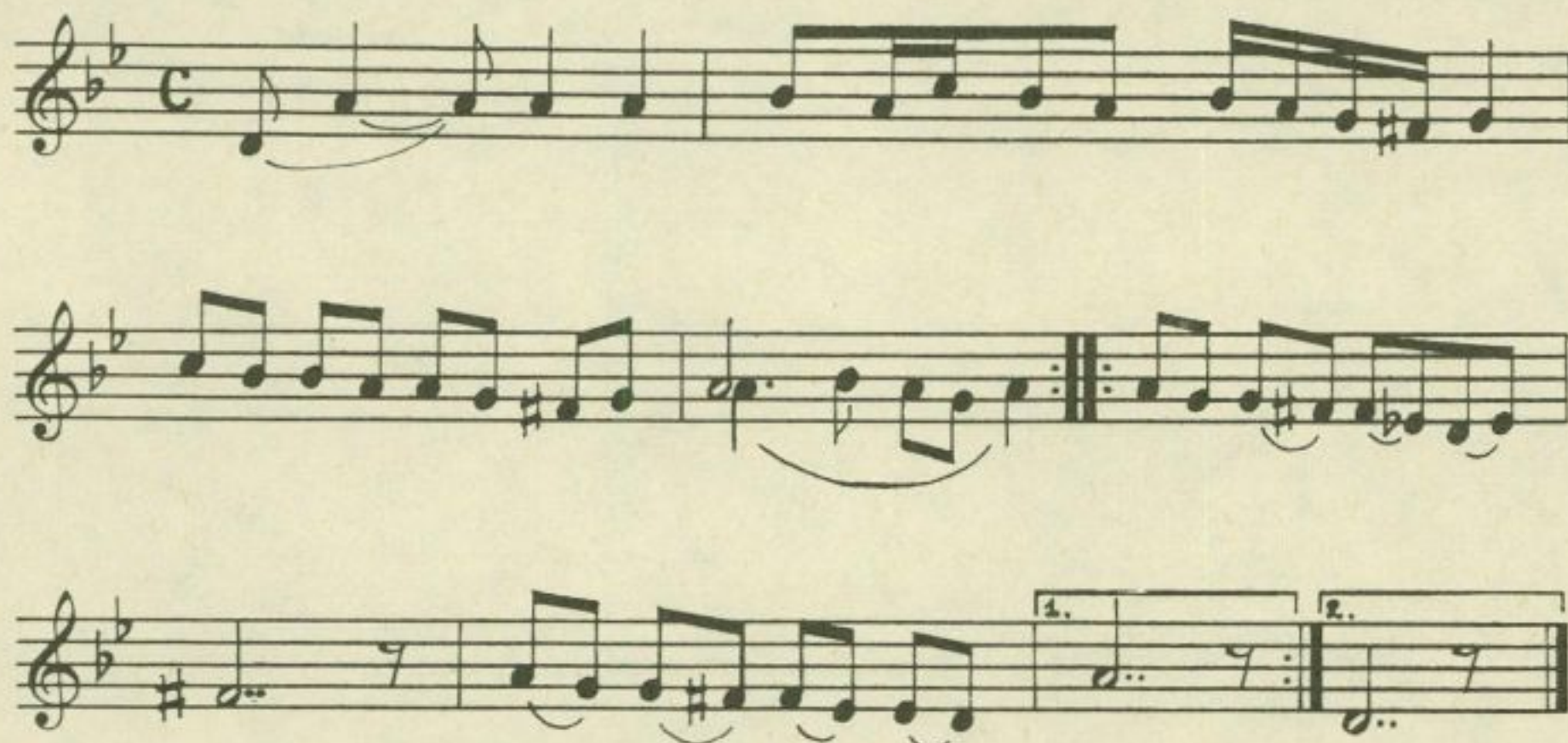
Hava nezē *be-maḥôl*   הבה נצא במחול

ᶜEẕ ha-rîmôn   עץ הרימון
(Persian tune)   (נעימה פרסית)
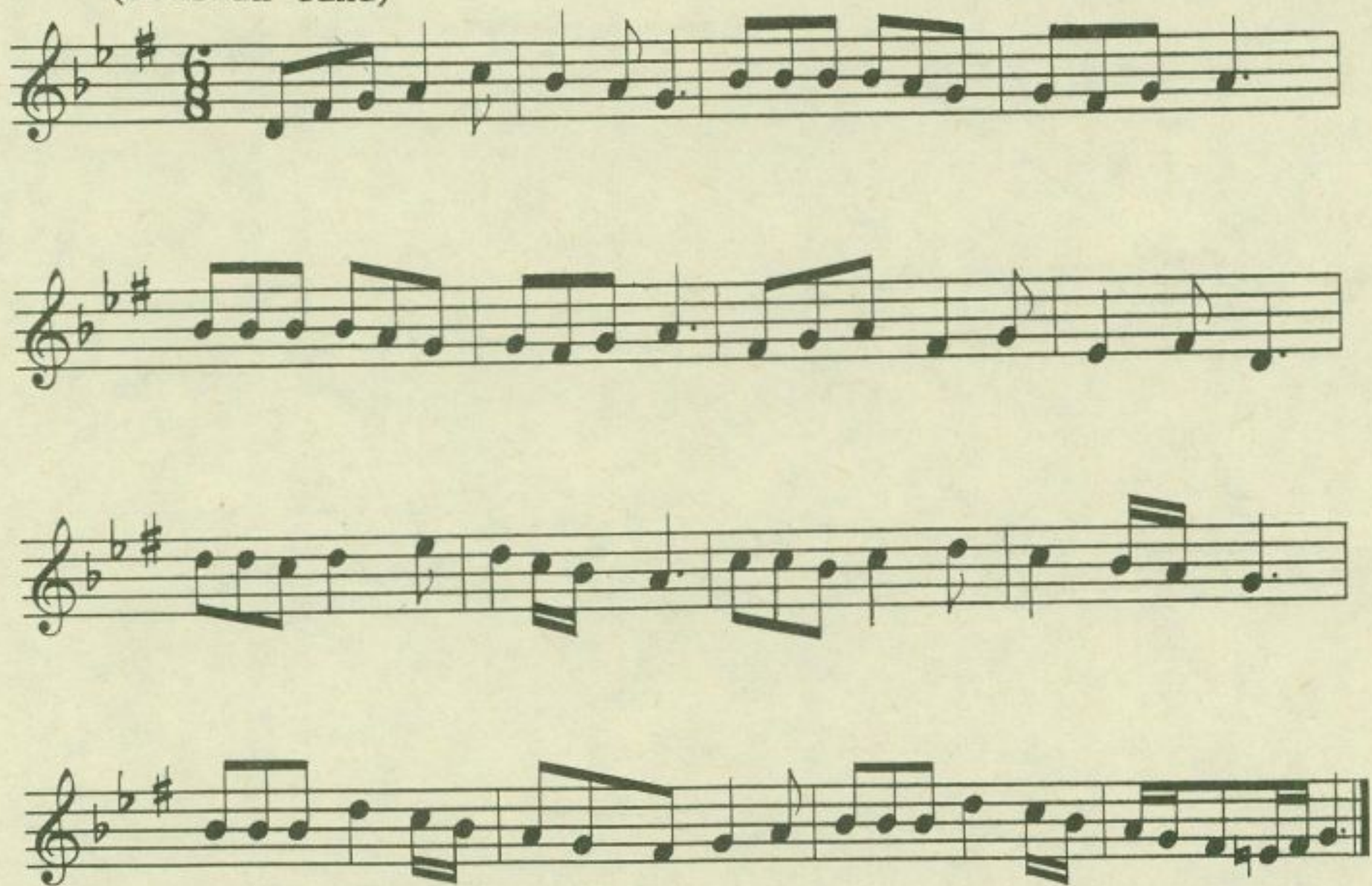
El yivneh hag-galîl   אל יבנה הגליל

fine

D.C.
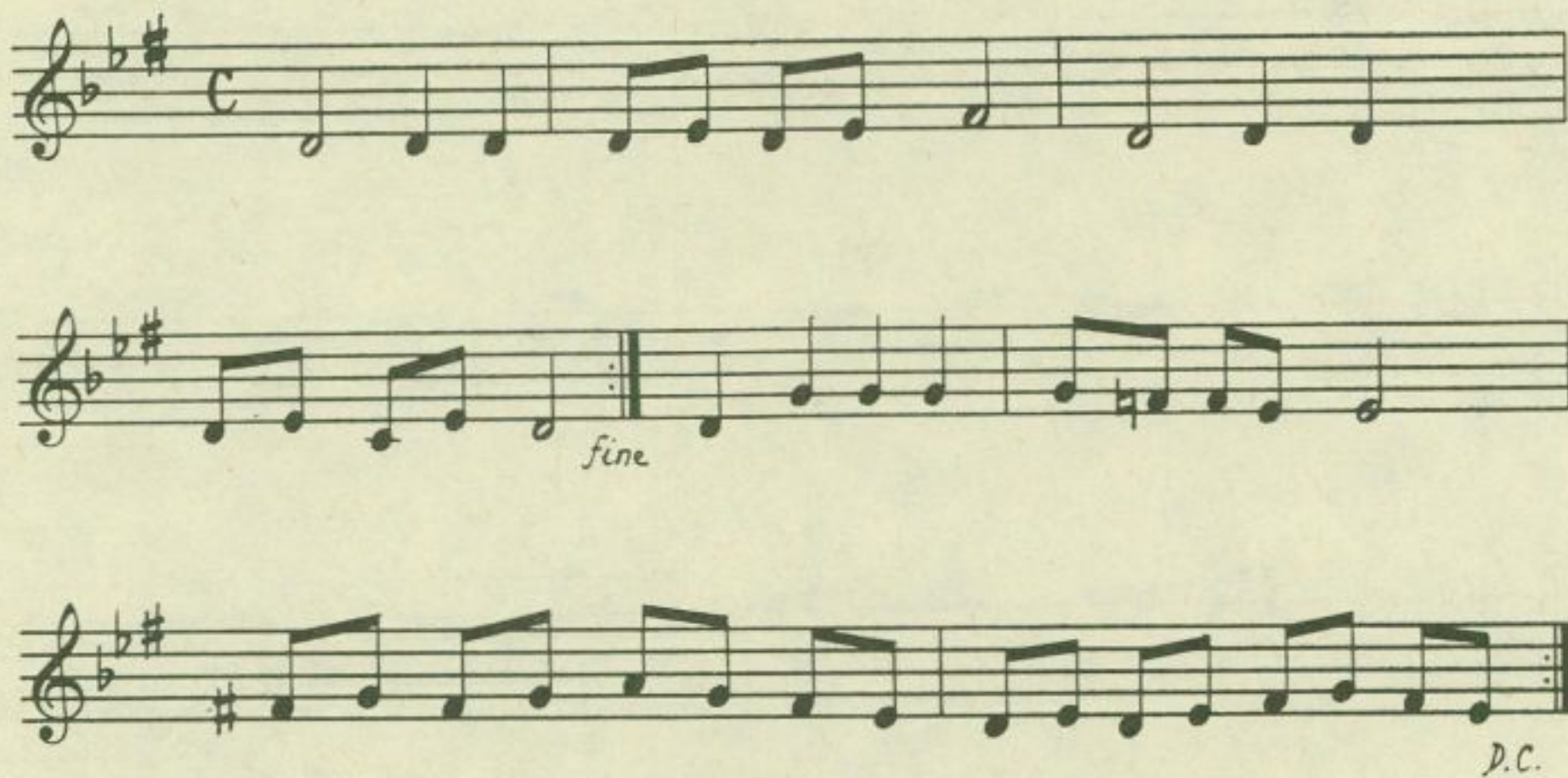
Bā haz-zemer (S. Cerem)   בא הזמר (ס. כרם)

We-dawid yefeh cênayim   ודוד יפה עינים
   (M. Shelem)   (מ. שלם)

Dûmam ša̱ṭah   דומם שטה
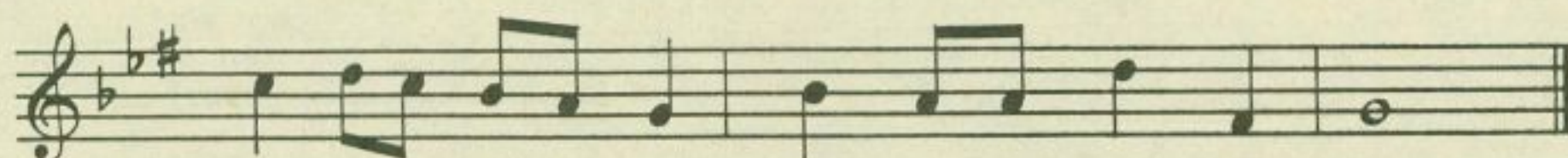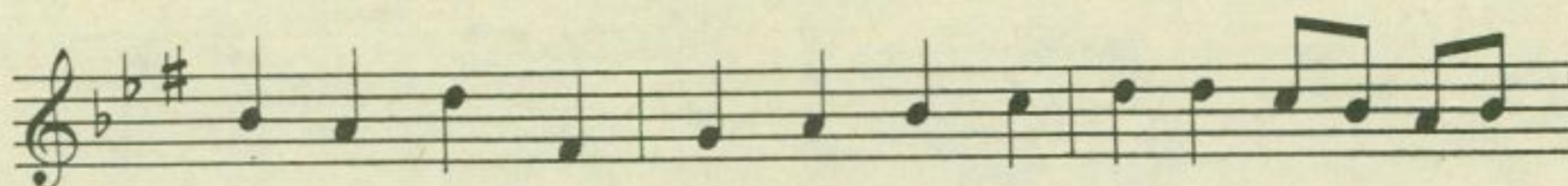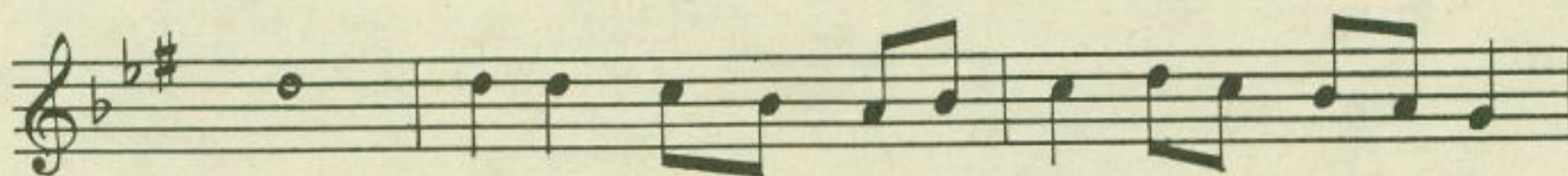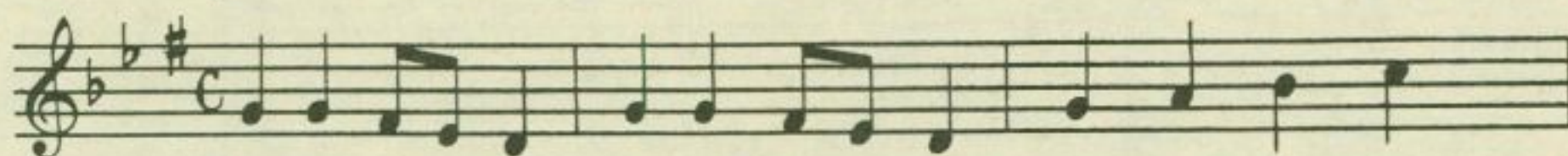
^cAl neharôt bavel   על נהרות בבל
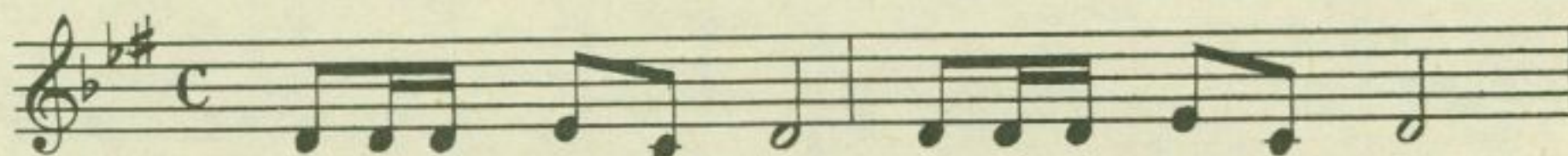
We-ṭaher libbenû
(Hassidic tune)

וטהר לבנו
(נעימה חסידית)
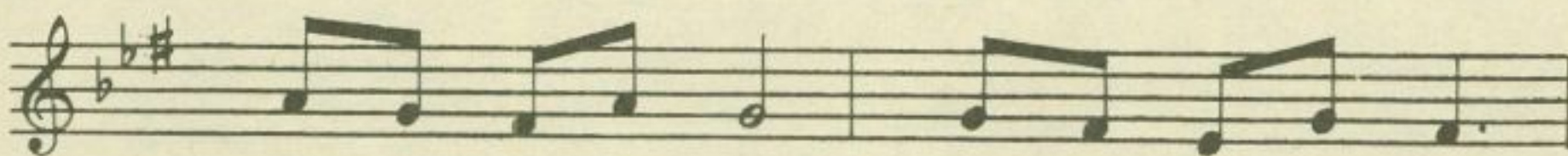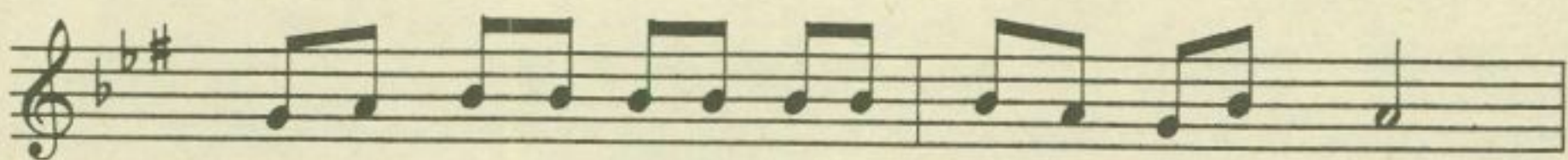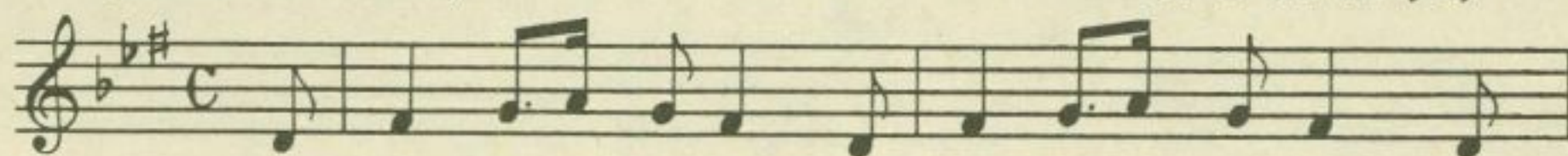
LIST OF SONGS

A. Awwazah šaṭah   B. Ten katef (M. Ze[c]ira)
    Sîmî yadek̲   Ḥûlû meḥôl ha-hôrah (M. Vilenski)
    Ḥat š(e)tayim šalôš '   Lanû hak-koaḥ (E. Amiran)
    Pirḥê avîv   Ken yōvedû (U. Giv'on)
    Mî dillel   [c]Al geva[c] ram (Y. Admon)
    Ha-avîv qarev û-vā   [c]Adarîm (M. Shelem)
    Hinneh hū bā (G.F. Händel)   Sîsû we-simḥû (M. Shelem)
    Perôs kenafêk̲a   Šîr han-nôded (S. Levi)
    Yônatan haq-qaṭan   Meḥôl avîv (Y. Hadar)
    Yoreh yaqar   Sallênû (Y. Admon)
                                         Hallelûyah (A. Ma'ayani)

C. Qôl dôdî (S. Levi)   D. Havah magîlah (Hassidic tune)
    Havû lanû yayin (M. Shelem)   [c]Et dôdîm kallah
    Mî zōt (S. Cerem)   Havah nezē be-maḥôl
    Sammeḥû levav (A. Ne'eman)   [c]Ez̲ ha-rîmôn (Persian tune)
    El ginnat egôz (S. Levi)   El Yivneh hag-galîl
    Debqa dalyah (E. Zamir)   Bā haz-zemer (S. Cerem)
    El ha-rahat (S. Levi)   We-dawid yefeh [c]ênayim (M. Shelem)
    Ḥag (E. Zamir)   Dûmam šaṭah
    Ba'ah menûḥah lay-yage[c]a   [c]Al naharôt bavel
      (D. Samburski)   We-ṭaher libbenû (Hassidic tune)
    Dôdî lî (N. Chen)
    Be'er bas-sadeh (E. Zamir)
    Z̲elîl zôgîm (E. Zamir)

דליה כהן * רות כץ

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ו

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