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LITHIUM IN THE HYADES, THE HYADES MOVING GROUP, AND PRAESEPE

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ABSTRACT

We have obtained high-resolution spectra of 35 F main-sequence stars at high signal-to-noise ratios in the region of the Li I resonance line at 6708 Å. Fourteen of the stars are members of the Hyades, six are members of Praesepe, and the remaining 15 stars are members of the Hyades Moving Group. We have measured equivalent widths of the Li resonance line and of Fe lines in the same spectral region and have calculated Li and Fe abundances from spectral synthesis using the model atmospheres of Kurucz. We find a mean metallicity of [Fe/H] = $+0.17 \pm 0.06$ for the Hyades, [Fe/H] = $+0.13 \pm 0.07$ for Praesepe, and [Fe/H] = $+0.11 \pm 0.09$ for the Hyades Moving Group. The pattern of Li abundance for the Hyades stars confirms that found earlier by Boesgaard and Tripicco for other members of the Hyades. The Li abundance for the six Praesepe stars are also consistent with this pattern. Some of the Hyades Moving Group members, however, do not fit this Li-temperature profile very well. If we use Li and Fe abundances as membership criteria for the F and G dwarfs in the Hyades Moving Group, only four in our sample appear to be members; the possibility exists, therefore, that the Hyades Moving Group is not coeval and that its members have little in common other than kinematics.

Subject headings: clusters: open — stars: abundances

I. INTRODUCTION

Recently Boesgaard and Tripicco (1986*a*) have shown that the pattern of Li abundance versus temperature for the Hyades F dwarfs is characterized by a sharp minimum near a temperature of 6650 K. The surface Li abundances show a dramatic drop of 2 or more orders of magnitude from log N(Li) = 3.0 [where log N(H) = 12.0] relative to both hotter and cooler stars with $T \geq 6850$ K and T near 6100–6300 K. A similar pattern is present in NGC 752 (Hobbs and Pilachowski 1986), the Coma cluster (Boesgaard 1987*a*), and the Ursa Major Group (Boesgaard, Budge, and Burck 1988), but not in the Pleiades (Boesgaard, Budge, and Ramsay 1988; Pilachowski, Booth, and Hobbs 1987) and α Persei clusters (Boesgaard, Budge, and Ramsay 1988).

The most likely explanation for the difference between these two groups is that the Pleiades and α Persei clusters are younger than the Hyades, Coma, and Ursa Major clusters. The Hyades are 7×10^8 years old, the Coma cluster is 5×10^8 years old, and the Ursa Major Group is 3×10^8 years old, while the age of the Pleiades is 7×10^7 years and that of α Persei is 2×10^7 years (Jones and Adler 1982; Barry, Cromwell, and Hege 1987). Michaud (1986) has interpreted the Li "chasm" of the F dwarfs in the older clusters as due to diffusion processes and has predicted that for younger clusters, such as the Pleiades, the chasm would be shallower and narrower. Stellar rotation may also play a role as discussed by Boesgaard and Tripicco (1986*a*) and Boesgaard (1987*b*).

If age is the primary parameter determining the Li abundance in F dwarfs, we may expect to see a pattern of Li abundance in Prasesepe that resembles that of the Hyades, since the two clusters are nearly identical in age. Likewise, the Hyades Moving Group, if it is coeval with the Hyades, should show the same pattern of Li depletion. We have therefore observed a sample of F dwarfs from Praesepe and the Hyades Moving Group. We have also expanded the sample of spectra of stars from the Hyades cluster itself and have included a few with $v \sin i$ somewhat larger than 30 km s^{-1}.

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II. OBSERVATIONS

We have observed 14 F dwarfs in the Hyades, 15 in the Hyades Moving Group, and five plus one spectroscopic binary in Praesepe. Table 1 gives the identification, the spectral type, $v \sin i$ (where available), the 2 σ signal-to-noise ratios (per pixel), and the adopted temperature for each star (see § III for a discussion of temperatures). The Hyades Moving Group members were selected from the lists of Eggen (1960, 1970). These stars were observed with the Palomar 5 m telescope on the nights of 1986 August 20 and 21, October 23 and 24, and November 10, 11, and 12 (UT dates). The 72 inch (1.8 m) coudé camera was used with an 800 × 800 liquid nitrogen–cooled Texas Instruments CCD. See Gunn *et al.* (1987) for a description of the Palomar CCD camera. The spectra were flat-fielded, wavelength-corrected, and continuum-fitted as described by Boesgaard, Budge, and Burck (1988). The signal-to-noise ratios were typically 300–500 for the Hyades and Hyades Moving Group stars, and 100–150 for the fainter Praesepe stars. Representative spectra are shown in Figures 1, 2, and 3 for the Hyades, Praesepe, and the Hyades Moving Group, respectively.

The continuum level was determined using a routine that fits a cubic spline through interactively selected continuum points. We measured equivalent widths by integration over the line profile, since the spectra have such high signal-to-noise ratios. Although in F dwarfs the minor blend due to Fe I is very small ($\lesssim$1–2 mÅ) this may contribute to the blue wing of the Li I 6708 Å line. We have accounted for the contribution of this line in our synthesis. Because there is still some uncertainty about the identity and parameters for this line, we have made the assumption in the case of very Li-depleted stars that the entire equivalent width is due to Li, and we give this as an

TABLE 1

STARS OBSERVED

A. HYADES

VB	HD	Spectral Type	$v \sin i$ (km s^{-1})	Signal/Noise (per pixel)	$T_{\rm eff}$ (K)
6......	24357	F4 V	59	445	7110
8......	25069	F5 V	54	340	6710
11......	26015	F3 V	25	360	6850
19......	29225	F8	≤12	340	6300
20......	26911	F3 V	55	230	6860
59......	28034	G0	≤6	500	6120
61......	28069	F5	18	310	6260
62......	28033	F8 V	5	300	6185
65......	28205	G0	9	420	6200
77......	28394	F7 V	25	320	6330
78......	28406	F6	20	295	6510
85......	28568	F5 V	53	260	6680
90......	28736	F5 V	35	380	6740
101......	29225	F5 V	40	380	6635

B. PRAESEPE

KW	BD	Spectral Type	Signal/Noise (per pixel)	$T_{\rm eff}$ (K)
142b.....	+20°2140	...	100	6650
142r.....	+20°2140	...	100	6450
227......	+19°2066	F5	150	6600
250......	+20°2157	F7	150	6395
295......	+20°2170	A8:	100	6605
332......	+19°2074	F2	120	6610
416......	+20°2183	F5	125	6805

C. HYADES MOVING GROUP

HR	HD	Spectral Type	$v \sin i$ (km s^{-1})	Signal/Noise (per pixel)	$T_{\rm eff}$ (K)
88......	1835	G2 V	7	300	5785
410......	8673	F7 V	32	400	6385
... .	17922	F8 V	...	345	6185
878......	18404	F5 IV	20	350	6620
... .	18975	dF7	...	330	6260
1001......	20675	F6 V	...	310	6545
... .	22328	F5 V	...	355	6360
1668......	33167	F5 V	...	355	6545
3202......	68146	F6 V	...	240	6225
5986......	144284	F8 IV	27	200	6195
... .	197039	F7 V	...	200	6510
8548......	212754	F7 V	7	200	6170
8772......	217877	F8 V	...	400	5965
8788......	218235	F6 V	...	400	6500
8792......	218261	F7 V	7	400	6150

upper limit on the Li abundance. (See discussion at the end of § III.) In the case of stars with more abundant Li the estimated contribution of the Fe line has been included in the calculated curves of growth, but this contribution is small.

One of our objects, KW 142, is a double-lined spectroscopic binary; we were able to resolve the two sets of lines and determine individual temperatures and abundances as described by Boesgaard and Tripicco (1986*b*). Because of the paucity of published $v \sin i$ values for Praesepe F dwarfs, we were unable to include rotation as one of our selection criteria, and some of our Praesepe stars are moderate rotators ($v \sin i \sim 30$ km s^{-1} for KW 332 and KW 295). The measured equivalent widths are given in Table 2.

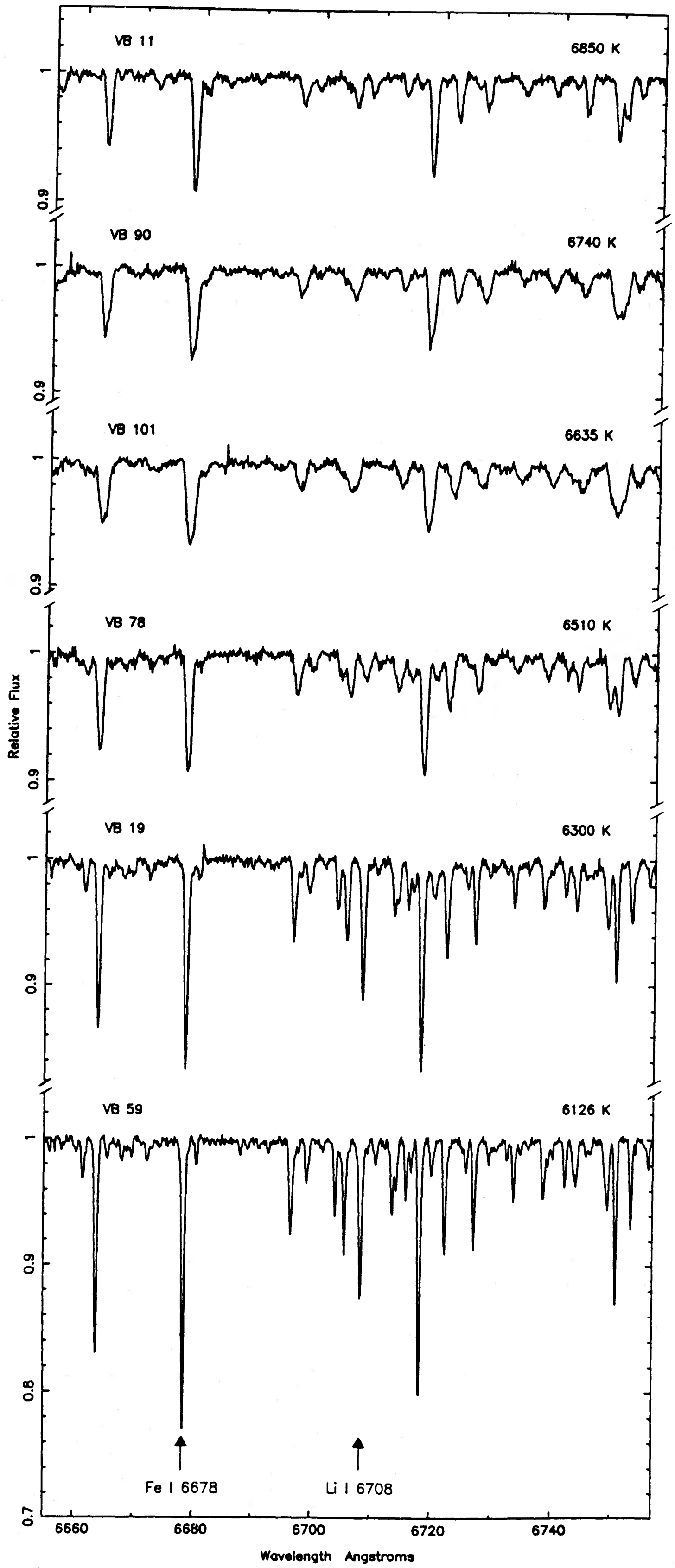

FIG. 1.—Representative spectra for stars in the Hyades in order of decreasing temperature. Note the changing ratios of I(Cr I λ6748)/I(Fe I λ6750) and I(Cr I λ6748)/I(Fe I λ6752) which are sensitive to temperature and confirm the photometric temperature calibration.

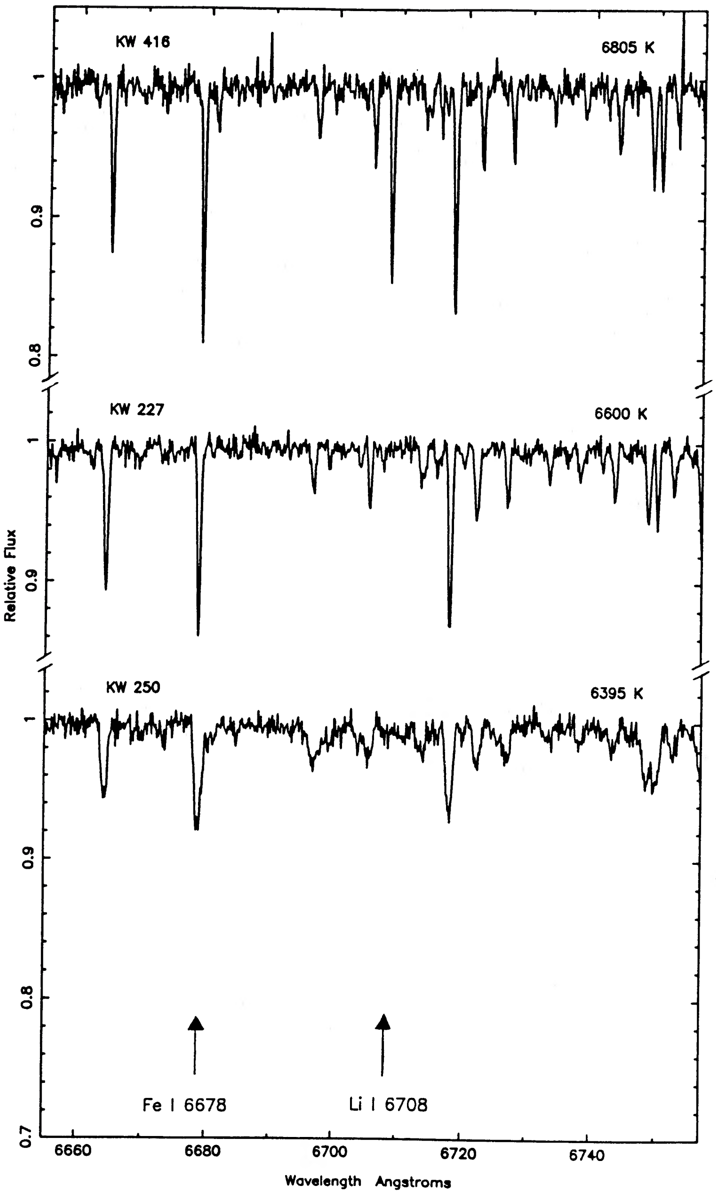

FIG. 2.—Representative spectra of stars in Praesepe

III. TEMPERATURES AND ABUNDANCES

In order to obtain useful abundances from the measured equivalent widths, it is necessary that we have accurate temperature estimates. In particular, the Li chasm in the Hyades is less than 400 K wide at log N(Li) = 3.0; thus, temperatures accurate to less than 100 K are needed to define properly the profile of the chasm. In the case of the Hyades, a large body of consistent photometric indices is available, and an accurate temperature calibration is relatively easy to determine. We have used the same photometric indices and temperature calibrations used by Boesgaard and Tripicco (1986*a*).

The temperatures for the Praesepe and Hyades Moving Group stars made use of several types of photometry: Strömgren Hβ and $(b-y)$ and Johnson $(B-V)$. The photometry is from Crawford and Barnes (1969), Crawford and Perry (1966), Johnson (1952), and the catalogs of Nicolet (1978) and Hauck and Mermilliod (1980). The calibrations and procedures adopted were those used for the Pleiades and α Persei stars, as described by Boesgaard, Budge, and Ramsay (1988). For HD 18975 we could find no published photometry; we used the average from the line ratio $I(6748)/I(6750)$ and the calibration in Boesgaard and Tripicco (1987) which gave 6250 K, and the equivalent width ratio $W(6703)/W(6705)$ with the Boesgaard and Tripicco (1986*b*) calibration which gave 6275 K, or 6260 K. For the spectroscopic binary KW 142 in Praesepe, only the line ratios, $I(6748)/I(6750)$ and $I(6748)/I(6752)$, could be seen clearly in the spectrum of the blueward-displaced star. They gave a temperature of about 6650 K. The lines in the redward-displaced spectrum are apparently blended, and only upper limits (<6650 K) could be found. That star is clearly cooler than KW 142b; a temperature of 6450 K was used. The equivalent widths were multipled by 1.836 and 2.198 for KW 142b and KW 142r, respectively, to correct for the differences in the Planck functions and radii as described by Boesgaard and Tripicco (1986*b*). The temperatures from various indices and calibrations and the adopted temperatures are given in Table 3.

After deriving temperatures for our objects in this manner, we determined the abundances from the measured equivalent widths and the temperature grid of the curves of growth. This is described by Boesgaard and Tripicco (1986*a*), but Nissen's (1981) values for the microturbulence parameter were used as done by Boesgaard (1987*a*) for the Coma cluster. The model atmospheres were those of Kurucz (1979). In order to reduce the effects of any departures from local thermodynamic equilibrium or errors in the atomic data, we compared the measured abundance for each Fe line with the abundance derived from the same line for the Sun and took the mean and then the log to obtain [Fe/H]. For the log N(Li) values, the presence of a very weak Fe I line at λ6707.441 was taken into account in the calculations with a value of [Fe/H] = +0.15. The results are virtually insensitive to the values of log g, microturbulence, or [Fe/H]. The results of the analysis are given in Table 4.

Special attention has been given to those stars for which the Li line is weak or absent. We have gone through our usual measurement procedure, which gives a value of a line "in the noise" with the width at the continuum of the other lines. This is a formal upper limit *measurement*. We can calculate a more realistic upper limit, the minimum detectable line, from the product of the line width (from $v \sin i$ and the factor between full width at half-maximum and the width at the continuum for a given $v \sin i$) and twice the peak-to-peak noise. The presence of the Fe I line λ6707.441 complicates the situation. Figure 4 shows the 6707 Å region in HR 878 with $T = 6620$ K, in the Li gap, where the Li I component is very weak and the Fe I component is present. (See Fig. 1 of Boesgaard and Lavery 1986 for other examples where the Fe I part of the blend can be easily seen.) In this case, the lines appear to be separate, so both were measured—Li I ≤ 2.9 mÅ and Fe I = 3.7 mÅ—and a separately measured total was 6.5 mÅ. The upper limit on the Li/H abundance can be found from the blended feature and curves similar to those in Boesgaard and Tripicco's (1986*b*) Figure 5, the synthesis of the line blend, or the Li I line limit only and curves like their Figure 4. The line blend method gives log N(Li) ≤ 1.76, while the Li I only gives a *lower* limit, log N(Li) ≤ 1.54. We have determined limits on Li/H as if the "minimum detectable" (but not detected) feature were *all* Li I. Since we note that the Fe I feature in a 6500 K star with solar Fe/H is predicted to be 2.3 mÅ, these upper limits are *very*

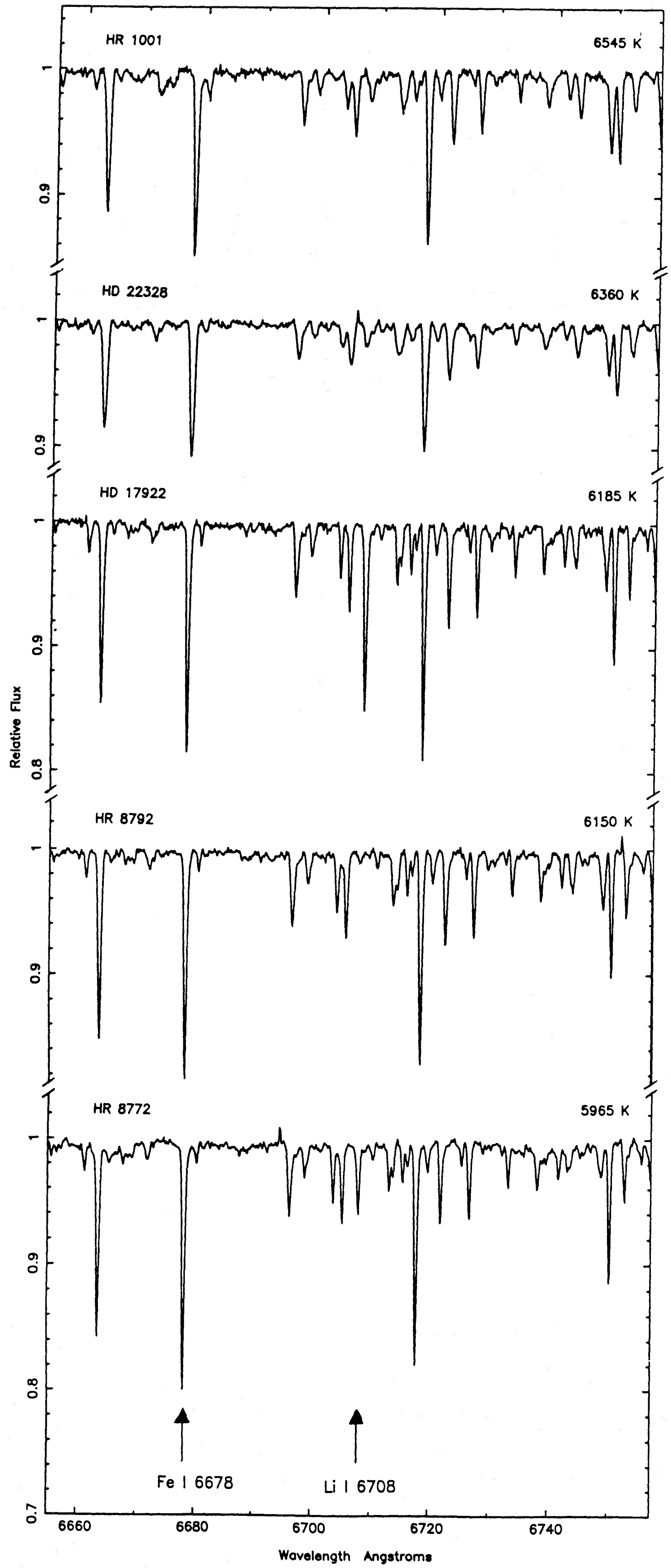

FIG. 3.—Representative spectra from the Hyades Moving Group. Note that HD 17922 and HR 8792 have nearly the same temperature, but much different lithium abundances, illustrating the scatter in lithium abundances evident in the moving group.

TABLE 2

EQUIVALENT WIDTHS[a] (mÅ)

A. HYADES

VB	HD	Fe I λ6677.493	Fe I λ6703.573	Fe I λ6705.117	Fe I λ6726.668	Fe I λ6750.152	Fe I λ6752.724	Li I λ6707.811
6..........	24357	101.5	...	20.8	23.9	...	13.8	54.8
8..........	25069	106.4	...	32.3	34.4	...	...	≤4.0
11..........	26015	105.7	12.7	30.5	26.7	37.0	14.8	19.4
19..........	29225	120.5	26.7	44.6	43.0	60.6	33.8	82.4
20..........	26911	92	14.6	32.9	41.6:	51.7	25.0	87.6
59..........	28034	127.7	30.4	50.6	45.9	61.0	33.0	85.0
61..........	28069	116.6	28.0	44.9	39.0	54.9	31.7	110.8
62..........	28033	114.0	30.2	45.9	36.8	64.9	32.9	131.2
65..........	28205	126.2	20.8	42.6	42.1	61.0	34.7	107.1
77..........	28394	111.5	23.6	42.5	30.8	53.9	30.4	29.8
78..........	28406	104.1	20.4:	39.3	34.9	53.4	28.2	32.6
85..........	28568	...	8.0	36.9	...	...	14.7:	≤6.0
90..........	28736	...	10.6	40.6	40.5	...	18.0	≤3.0
101..........	29225	114.7	14.5	41.4	32.5	...	24.3	≤ 3.0

B. PRAESEPE

KW	BD	Fe I λ6677.493	Fe I λ6703.573	Fe I λ6705.117	Fe I λ6726.668	Fe I λ6750.152	Fe I λ6752.724	Li I λ6707.811
142b.........	+22°2140	99	17.4	...	28.8	...	22.0	≤8.0
142r.........	+20°2140	120	...	...	38.7	...	...	22.2
227..........	+19°2066	90.9	11.4	27.7	30.1	32.6	29.6	12.3
250..........	+20°2157	103.7	20.6	37.3	33.9	59.9	28.7	18.4
295..........	+20°2170	124.8:	15.2	32.2:	25.6:	...	...	30.7:
332..........	+20°2074	110.4	12.3	38.4	25.3	57.9	24.7	≤14.8
416..........	+20°2183	99.6	13.0	32.9	31.5	42.5	...	83.5

C. HYADES MOVING GROUP

HR	HD	Fe I λ6677.493	Fe I λ6703.573	Fe I λ6705.117	Fe I λ6726.668	Fe I λ6750.152	Fe I λ6752.724	Li I λ6707.811
88.........	1835	162.1	39.6	57.4	53.6	76.5	52.8	88.0
410.........	8673	101.9	26.7	41.2	38.5	56.5	32.9	12.3
... .	17922	114.8	19.1	41.9	35.6	57.8	29.6	94.7
878.........	18404	98.2	9.3	20.8	36.0	43.5	24.3	≤6.5
... .	18975	112.5	23.7	42.3	32.2	51.9	26.1	27.5
1001.........	20675	111.0	23.9	42.4	32.2	51.9	26.1	27.5
... .	22328	112.3	22.5	40.5:	35.4	50.9	22.8	28.3
1668.........	33167	114.7	9.4	38.1	32.8	...	25.8	36.1
3202.........	68146	95.3	17.2	29.4	38.3	47.3	22.4	41.3
5986.........	144284	132.1	35.7	53.0	49.6	64.6	35.1	≤15.3
... .	197039	...	20.8	31.4	40.7	52.8	38.5	41.8
8548.........	212754	112	24.4	38.8	29.1	53.3	31.2	12.5:
8772.........	217877	114.9	30.1	39.0	33.7	54.5	29.9	35.3
8788.........	218235	116.1	23.9	47.6	44.2	54.9	40.2	≤9.4
8792.........	218261	115.9	33.7	44.6	44.8	55.9	33.9	10.0

[a] The values listed under Li I are combinations of Li I and Fe I λ6707.441.

conservative. We give the estimates that include Fe in the blend in parentheses in Table 4.

IV. RESULTS AND DISCUSSION

The [Fe/H] results in Table 4 are plotted as a function of temperature in Figures 5, 6, and 7. There is a small systematic trend with temperature for the Hyades stars hotter than about 6600 K; this indicates that the temperature calibration, based on Carney (1983) and Cayrel, Cayrel de Strobel, and Campbell (1985), gives temperatures that are slightly too high for the hotter stars. The temperature scale for the other groups seems uniform and self-consistent, but there is more scatter in the [Fe/H] values. The larger dispersion in the Hyades Moving Group stars may be due to the variety of different sources for the photometric indices used to obtain the temperatures, or it may be a real dispersion in [Fe/H], calling into question the reality of the Hyades Moving Group.

When all 40 stars plotted in Figure 5 are used to determine the average value of Fe/H for the Hyades, the log of that is $[Fe/H] = 0.156 \pm 0.064$ (the standard error of the mean). The 31 F stars analyzed here and by Boesgaard and Tripicco (1986*a*) give $[Fe/H] = +0.168 \pm 0.064$. For the five Praesepe stars (excluding the spectroscopic binary) the mean Fe/H gives $[Fe/H] = +0.132 \pm 0.067$. Although it is not clear that all the

TABLE 3

TEMPERATURES (K)

A. HYADES

VB	$T(V-K)$	$T(V-K)_{calc}$	$T(V-I)$	T (adopted)
6	...	7107	7238	7105
8	...	6710	6830	6710
11	...	6822	6873	6845
19	...	6290	6315	6300
20	6860	6810	6830	6860
59	6070	6165	6137	6120
61	...	6280	6240	6260
62	...	6185	6505	6185
65	6200	6195	6207	6200
77	...	6330	6240	6330
78	6512	6549	6542	6512
85	(6565)	6680	6580	6680
90	...	6738	6663	6738
101	...	6645	6620	6635

B. PRAESEPE

KW	$T(\beta)$	$T(b-y)$	$T(B-V)_0$	T (adopted)
227	6620	6580	6605	6600±20
250	6450	6325	6410	6395±65
295	6630	6595	6595	6605±20
332	6765	6540	6525	6610±135
416	6735	6710	6960	6805±140
142b	...	...	...	6650
142r	...	...	...	6450

C. HYADES MOVING GROUP

HR/HD	$T(\beta)$	$T(b-y)$	$T(B-V)_0$	T (adopted)
88	...	5865	5705	5785
410	6490	6345	6405	6385±35
17992	...	6195	6175	6185
878	...	...	6620	6620
18975	...	...	...	6260[a]
1001	...	...	6545	6545
22328	...	...	...	6360[b]
1668	6620	6430	6580	6545±100
3202	6160	6195	6325	6225±45
5986	6280	6095	6210	6195±95
197039	...	...	6510	6510
8548	6075	6230	6210	6170±85
8772	5915	5995	5990	5965±45
8788	6520	6460	6515	6500±35
8792	6000	6120	6330	6150±165

[a] Temperature from calibrated line ratios. See text.

[b] Temperature from Eggen's 1970, 1982 photometry reduced by 25 K to match scale used here.

TABLE 4

DERIVED ABUNDANCES

Name	T_{eff} (K)	[Fe/H]	σ	log N(Li)[a]
A. Hyades				
VB 6	7110	+0.30	0.06	3.27
VB 8	6710	+0.20	0.03	≤1.75(≤1.46)
VB 11	6850	+0.30	0.05	2.48
VB 19	6300	+0.18	0.03	2.85
VB 20	6860	+0.27	0.14	3.30
VB 59	6120	+0.14	0.06	2.79
VB 61	6260	+0.11	0.05	3.04
VB 62	6185	+0.11	0.09	3.03
VB 65	6200	+0.12	0.08	2.98
VB 77	6330	+0.10	0.07	2.35
VB 78	6510	+0.11	0.04	2.50
VB 85	6680	+0.12	0.31	≤1.90(≤1.72)
VB 90	6740	+0.13	0.05	≤1.65(≤1.26)
VB 101	6635	+0.19	0.15	≤1.58(≤1.11)
B. Praesepe				
KW 142b	6650	+0.09	0.05	≤2.02(≤1.90)
KW 142r	6450	+0.22	0.10	2.28
KW 227	6600	+0.01	0.13	2.06
KW 250	6395	+0.11	0.10	2.11
KW 295	6605	+0.19	0.28	2.57
KW 332	6610	+0.16	0.17	≤2.18
KW 416	6805	+0.17	0.05	3.25
C. Hyades Moving Group				
HR 88	5785	+0.16	0.13	2.51
HR 410	6385	+0.14	0.07	1.85
HD 17922	6185	+0.02	0.03	2.89
HR 878	6620	+0.04	0.15	≤1.54(≤1.76)
HD 18975	6260	+0.05	0.06	2.69
HR 1001	6545	+0.20	0.08	2.42
HD 22328	6360	+0.07	0.08	2.33
HR 1668	6545	+0.09	0.25	2.63
HR 3202	6225	−0.01	0.25	2.44
HR 5986	6195	+0.23	0.06	≤1.82
HD 197039	6510	+0.21	0.11	2.69
HD 8548	6170	+0.06	0.17	1.67
HR 8772	5965	−0.01	0.11	2.11
HR 8788	6500	+0.23	0.06	≤1.84
HR 8792	6060	+0.10	0.08	1.47

[a] The values in parentheses correspond to those determined from the synthesis of the Li + Fe I blend; other upper limits are from the more conservative assumption that the limit on the equivalent width corresponds to Li I only.

stars we observed are, in fact, Hyades Moving Group members (see below), the global average for Fe/H for those 15 stars is [Fe/H] = +0.114 ± 0.087.

The Li abundances obtained for the Hyades are plotted in Figure 8. Open symbols represent the objects measured in this study; filled symbols represent Hyades stars measured by Boesgaard and Tripicco (1986*a*) and by Cayrel *et al.* (1984). It is evident that the additional Hyades stars measured in this study help to define further the Li-temperature profile found in the earlier results. The explanation for the phenomenal depletion of Li in the mid-F dwarfs may be in diffusion processes as calculated by Michaud (1986), but may also be connected to rotation/differential rotation as discussed by Boesgaard and Tripicco (1986*a*) and Boesgaard (1987*b*). More calculations of both effects are needed.

Figure 9 shows the Li abundances in the Praesepe stars superposed on the Hyades results. These Li results are consistent with those for the Hyades, although there are not enough objects to define the Li chasm at 6700 K clearly.

The values of log N(Li) for the Hyades Moving Group objects, on the other hand, are quite discrepant, as can be seen in Figure 10, where they are plotted with the Hyades results. We note that three objects on the cool side of the gap, HR 5986, HR 8548, and HR 8792, have a much lower Li abundance than any stars with similar temperatures in the Hyades. Indeed, the plot of Li abundance versus temperature

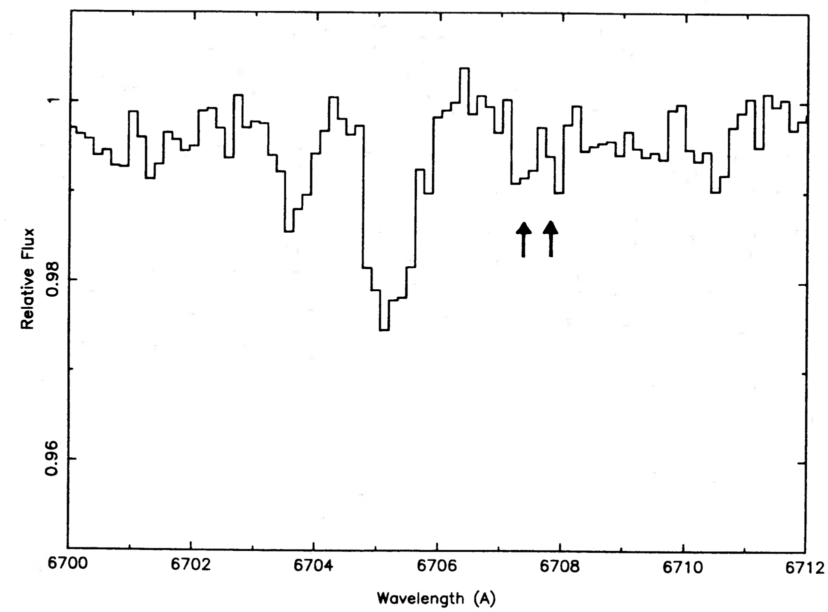

FIG. 4.—Region near the Li I line on an expanded scale for HR 878, which has $T = 6620$ K (in the Li "gap") and $v \sin i = 20$ km s^{-1}. This spectrum has S/N = 400. The positions of the Li I feature at 6707.81 Å and the Fe I feature at 6707.44 Å are indicated.

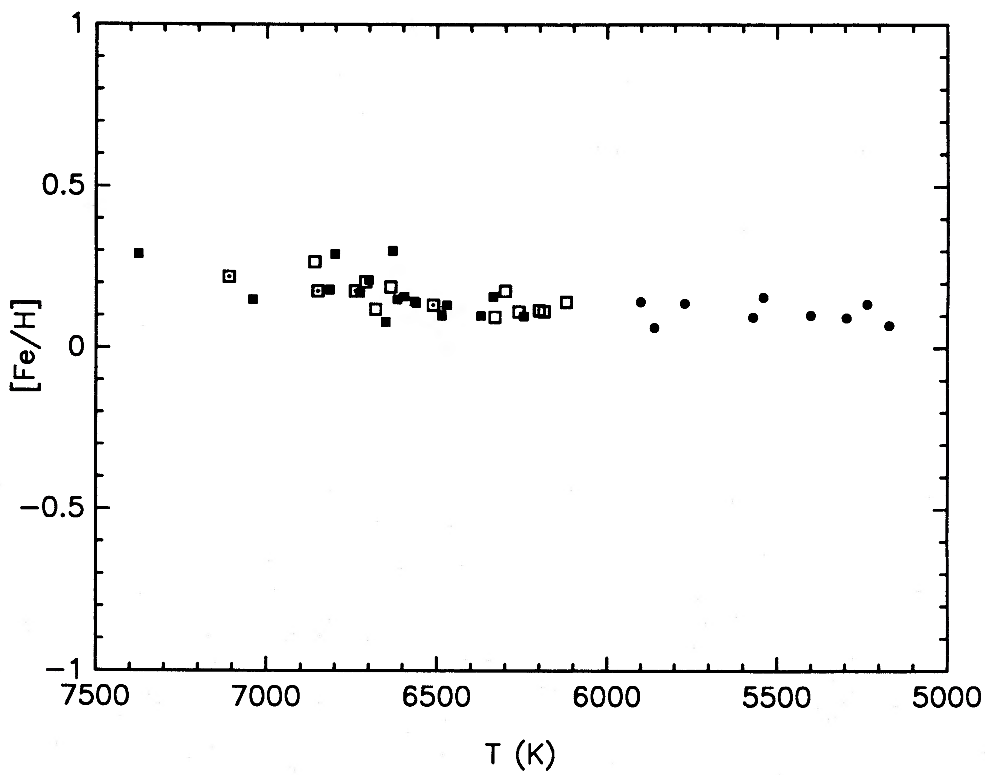

FIG. 5.—[Fe/H] vs. temperature for the Hyades. Filled squares represent observations of Boesgaard and Tripicco (1986*a*), filled circles are results from Cayrel *et al.* (1984), while open symbols are objects studied in this paper. Open symbols with a dot inside represent objects done both by Boesgaard and Tripicco (1986*a*) and here, and the weighted averages are plotted.

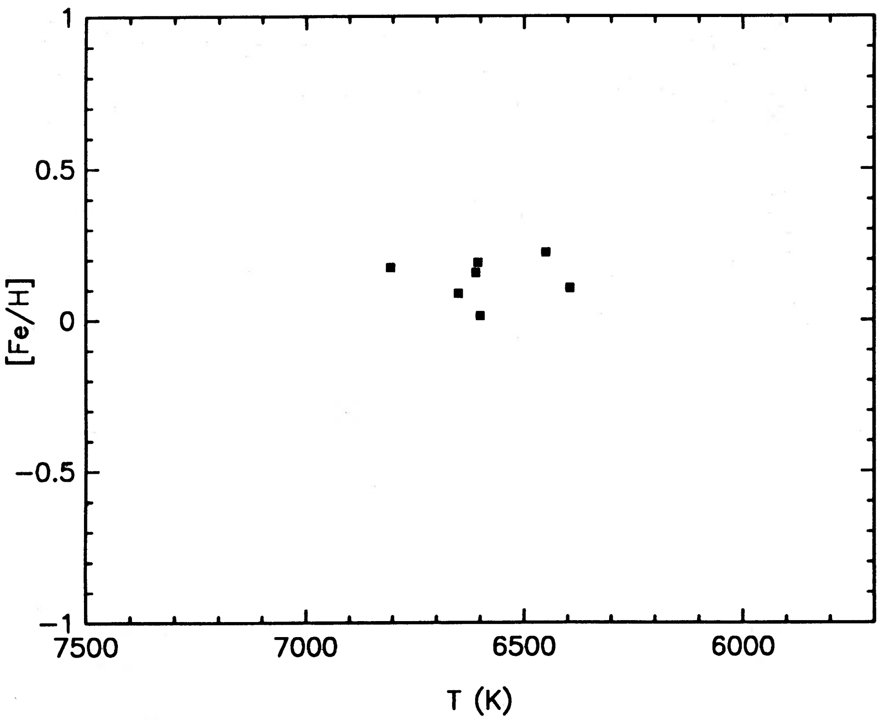

FIG. 6.—[Fe/H] vs. temperature for Praesepe

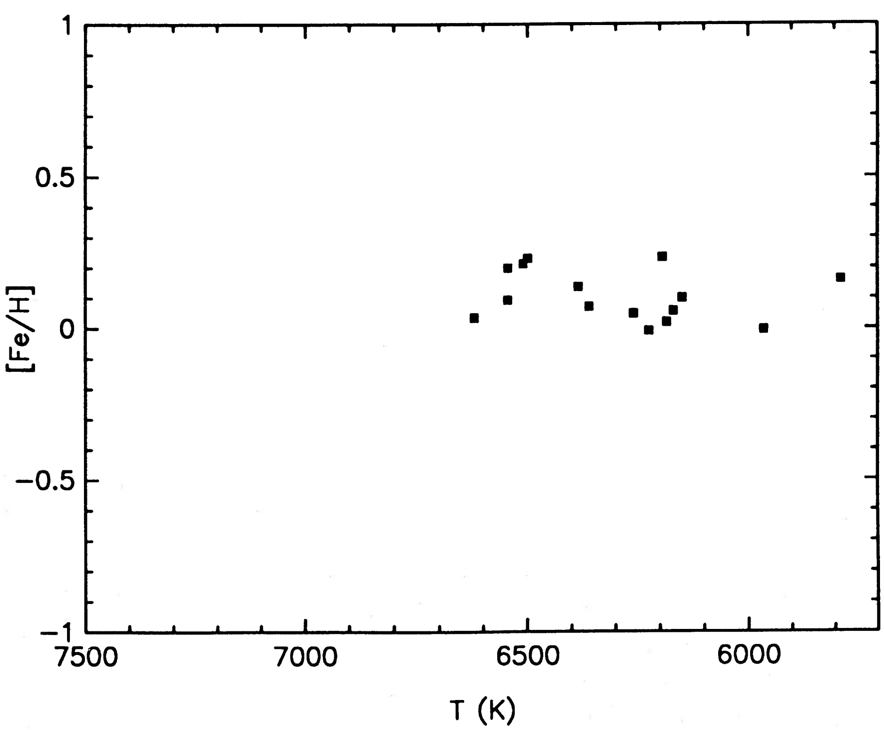

FIG. 7.—[Fe/H] vs. temperature for the Hyades Moving Group

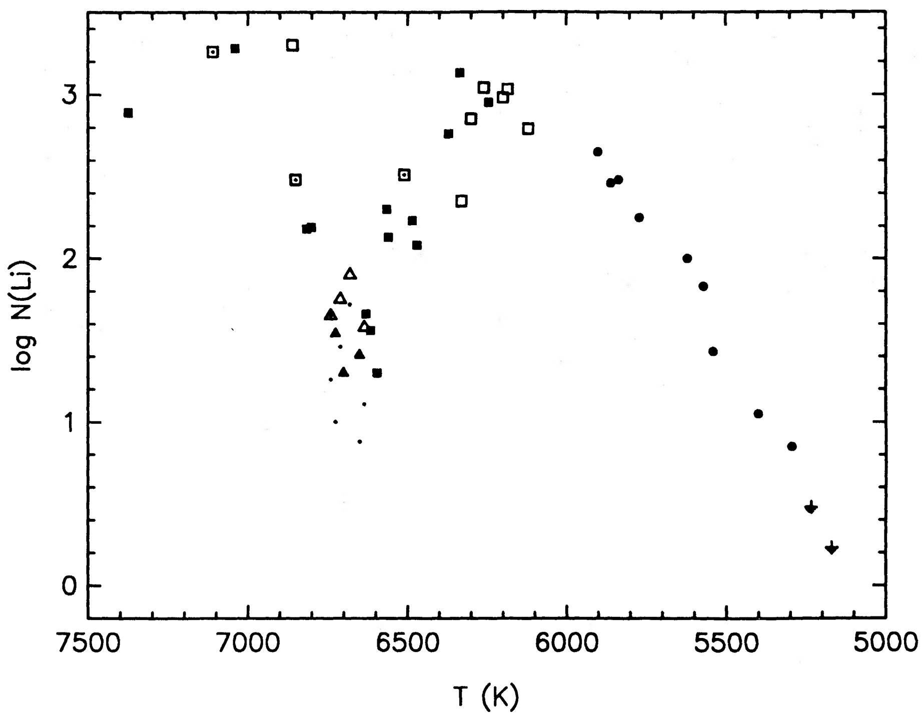

FIG. 8.—Lithium abundance [on the scale where log $N(\mathrm{H}) = 12.00$] plotted against temperature for the Hyades. Filled squares and triangles represent results of Boesgaard and Tripicco (1986*a*), filled circles are results from Cayrel *et al.* (1984), while open symbols are objects studied in this paper. Open symbols with a dot inside represent objects done both by Boesgaard and Tripicco (1986*a*) and here, and the weighted averages are plotted. Triangles denote upper limits, but the small dots indicate the upper limits found from the Li–Fe blend synthesis for the F dwarfs.

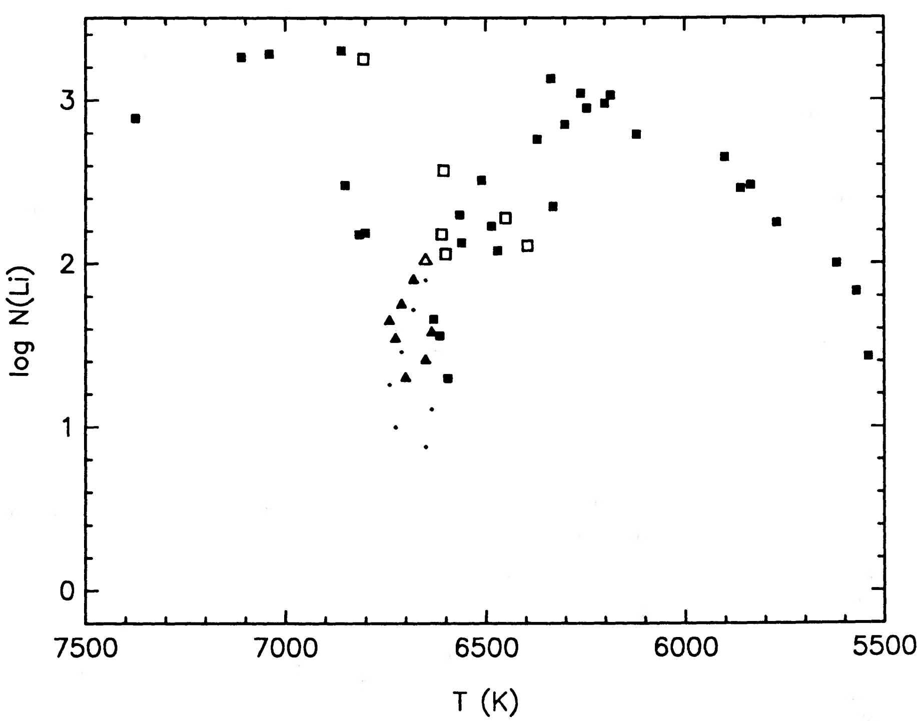

FIG. 9.—Lithium abundance vs. temperature for Praesepe (*open symbols*). Results from the Hyades (*filled symbols*) are also given for comparison. Triangles denote conservative upper limits, with the dots representing the Fe–Li blend limits.

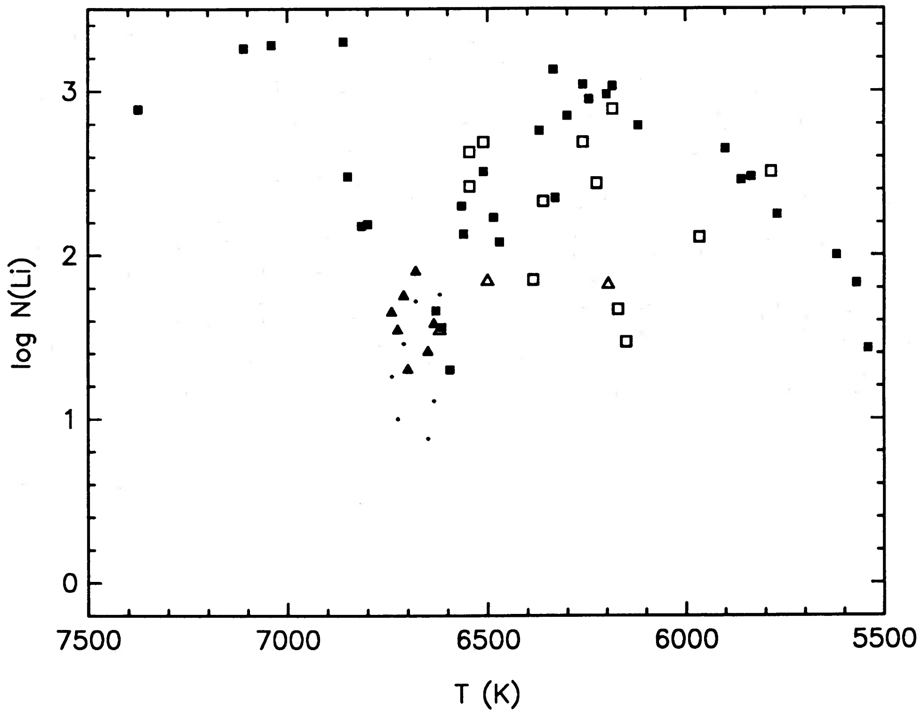

FIG. 10.—Lithium abundances vs. temperature for the Hyades Moving Group (*open symbols*). Results from the Hyades (*filled symbols*) are also given for comparison. Triangles denote upper limits, dots the additional upper limits from the Hyades Li–Fe blend calculations.

for the Hyades Moving Group resembles a scatter diagram. There is no clearly defined Li-temperature trend at all. This discrepancy cannot be accounted for by the uncertainties in the temperatures, which are less than about 100 K.

There are three possible explanations for this discrepancy. The first and most obvious is that the Hyades Moving Group has no physical significance—in other words, that the common space velocity of its members is accidental and the stars in the group are not coeval with one another or the Hyades. This hypothesis is supported by the larger scatter in the derived Fe abundances for the group compared with the Hyades cluster itself.

The second possibility is that the Hyades Moving Group is real, but that lists of possible members include a great many nonmembers which have obscured the true abundance patterns of the group. This hypothesis would be supported by a finding that the objects showing the largest discrepancies from the Hyades Li pattern also show large Fe abundance and kinematic discrepancies. The stars which have Hyades-like values for both [Fe/H] and log N(Li) may well belong to the Hyades large-scale cluster. In fact, only four of our 15 stars fit both the Hyades Li pattern and the Hyades [Fe/H] (+0.07 to +0.20): HR 88, HR 1001, HD 22328, and HR 1668. Those four stars match the Hyades (U, V, W = +40, −17, −3 km s^{-1}) very well in U and V velocities—39 ± 1 km s^{-1} in U, all at −17 km s^{-1} in V—but show a spread in W of −17 to +3 km s^{-1}. Our potential "rejects" agree less well in U as well as in W.

The third possibility is that the Hyades Moving Group is real, but that there is a second parameter (other than age) significant in determining the Li pattern which is different for the Hyades Moving Group stars than for the cluster members. For example, one could hypothesize that the group members had lower initial rotational velocity than the cluster members because their angular momentum went into orbital motion instead (thus causing them to be part of the extensive Hyades Moving Group instead of the compact cluster.) The UMa group shows the Hyades Li pattern, however, which argues against such a mechanism.

If age is the second parameter, it is possible that the Hyades Moving Group stars were formed first and are less gravitationally bound to the cluster and thus show effects of disruption or greater separation from the central part of the cluster. If this were the case, the older stars would show greater Li depletions. This is true for some, but by no means all, of the Hyades Moving Group stars. There is evidence that both the Pleiades (Butler *et al.* 1987) and NGC 752 (Twarog 1983; but see Beckman and Rebolo 1988) show two episodes of star formation. The younger sequences would contain more Li.

There is no doubt about the reality of the Li dip in the Hyades from this enlarged sample of 32 F dwarfs. The Praesepe stars fit well with this pattern, although more stars should be observed to confirm this. The Hyades Moving Group does not appear to be a cohesive or coeval group linked with the Hyades, as judged by the scatter in the Li and the Fe abundances.

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