GRAZING EFFECTS ON THE STRUCTURE AND DYNAMICS OF GRASSLAND ECOSYSTEMS
Project No. 1786

Complementary Rotation Grazing System in Western North Dakota

L.L. Manske, M.E. Biondini, C.Y. Oseto, J.E. Struble, D.O. Erickson, P.J. Sjursen, T.J. Conlon, J.L. Nelson and D.G. Landblom

Introduction

Complementary grazing uses domesticated grass, legume, or annual crop pastures to add to or complement native range pastures. Rotation grazing moves livestock through a successive series of pastures in a preplanned sequence. Management of native range and domesticated grass pastures must be based on sound ecological principles that consider the growth and development of the dominant species and the physiological needs, weaknesses and strengths of the plants to maintain productive stands. The nutritional needs of the livestock must be included in management considerations. Sound management recommendations can only be based on reliable scientific research.

Procedures

This revised project compares nongrazed, seasonlong grazing and rotation grazing on three native range sites to evaluate species composition, herbage production, and animal performance and the use of domesticated grass pastures in a complementary rotation grazing system. The present complementary rotation grazing system has been in place at the ranch headquarters of the Dickinson Experiment Station since 1983. It consists of a crested wheatgrass (Agropyron desertorum) pasture for spring grazing and an altai wildrye (Elymus angustus) pasture for fall and early winter grazing. Native range has been grazed during the summer and managed with a three pastures, twice over rotation system. The seasonlong pasture treatments were established in 1986 and grazed from mid June to late October. The nongrazed treatment plots were established in 1987 and have not been grazed for more than 30 years.

The intended purpose of the trial is to maximize herbage and livestock production for a cow-calf operation, lengthen the grazing season in the spring and fall, improve range condition of native range, and reduce total acreage required to carry a cow and calf. The intention is to accomplish these goals with a low number of pastures with few rotation times and be flexible enough to be adapted by a wide range of livestock operations. This type of grazing system should improve operation efficiency, reduce costs and decrease labor per unit of production, and increase saleable production per acre.

Data collected on the treatments in this study are above ground herbage production, plant species composition, leaf height measurements and phenological phases of eight major graminoid species, and animal weight performance. Commercial crossbred cattle are used in this trial.

Results and Discussion

Total plant basal cover (Table 1) was greater on ungrazed range sites of rotation treatments compared to nongrazed range sites. Total plant basal cover (Table 1) on the seasonlong grazed treatments was greater than on the rotation grazed treatments.

Total live herbage (Table 2) in July was greater on the shallow and silty range sites of the rotation treatments ungrazed plots compared to ungrazed plots of the seasonlong and nongrazed treatments. Total live herbage was greater on the sandy range sites of the seasonlong treatments ungrazed plots compared to the rotation and nongrazed treatments.

Periodic weights of cows and calves are on Table 3 and average daily gain and gain per acre are on Table 4. Cows on seasonlong treatments lost weight after 15 September. These cows lost an average of 78 pounds during the last 47 days on pasture for a loss of 1.66 pounds per day. Cows on the complementary rotation treatments lost weight after 1 October. These cows lost an average of 54 pounds during the last 84 days of grazing for a mean loss of 0.64 pounds per day.

On native range, cows on the rotation treatments gained 0.71 pounds per day for a total gain of 10.5 pounds per acre. The cows on the seasonlong treatments gained 0.23 pounds per day for a total gain of 3.5 pounds per acre. Calves on the seasonlong native range treatments gained 303 pounds in 129 days for an average daily gain of 2.35 pounds. Calves on the rotation native range treatments gained 338 pounds in 136 days for an average daily gain of 2.43 pounds. Calves on the rotation treatments gained 36.2 pounds per acre and calves on the seasonlong treatments gained 35.4 pounds per acre.

Summary

The management of this complementary rotation grazing system has been based on ecological principles that consider the physiological needs, weaknesses, and strengths of the dominant plant species. Consideration of the nutritional needs of the livestock have been incorporated. Season of use of each pasture type was limited to periods of grazing when the detrimental effects of grazing were minimized and the potential for improvement in animal weight performance was maximized to near potential. Effort has been made to limit the number of pastures and rotation times to the minimum. One pasture of crested wheatgrass was used for spring grazing. A second pasture may be necessary to move the starting date earlier. The native range was managed with three pastures, each grazed two times during the grazing season. One pasture of altai wildrye was used in this system for fall and early winter grazing. The grazing season has been lengthened from the traditional 6 months to 7.1 months. This system has the potential to lengthen the grazing season to 8.0 months with additional research. The acreage required to carry a cow and calf was reduced from 24.4 acres for 6 months to 11.6 acres for 7.1 months.

By using a complementary rotation grazing system similar to the one at the Dickinson Experiment Station, livestock producers have the potential to: lengthen the grazing season, reduce the acreage required to feed a cow and calf, and increase the amount of saleable beef produced from each livestock unit.

TABLE 1. Mean Percent Basal Cover for Native Range Treatments, Dickinson Experiment Station, July, 1987

RANGE SITE Treatment	Grass	Sedge	Forb	Shrub	Other Plant	Total Plant	Litter	Soil
SANDY								
Ungrazed								
Nongrazed	11.1	9.9	1.8	0.1	0.0	22.8	77.2	0.1
Seasonlong	---	---	---	---	---	---	---	---
Rotation	9.9	10.2	3.7	0.1	0.6	24.6	68.2	7.2
Grazed								
Seasonlong	12.8	11.0	3.0	0.4	0.1	27.2	71.2	1.5
Rotation	9.2	11.4	3.5	0.4	0.3	24.8	66.5	8.7
SHALLOW								
Ungrazed								
Nongrazed	8.9	9.9	5.4	0.6	0.0	24.7	71.9	3.4
Seasonlong	---	---	---	---	---	---	---	---
Rotation	16.9	5.2	3.1	0.1	3.3	28.6	58.0	13.4
Grazed								
Seasonlong	13.6	7.8	4.4	0.4	3.0	29.2	61.9	8.9
Rotation	17.6	5.7	3.0	0.2	1.1	27.5	59.0	13.5
SILTY								
Ungrazed								
Nongrazed	12.3	11.4	2.3	0.4	0.0	26.4	73.3	0.4
Seasonlong	19.6	3.1	4.7	0.0	0.5	27.9	70.4	1.6
Rotation	17.4	3.7	6.2	0.0	0.2	27.5	66.8	5.7
Grazed								
Seasonlong	18.4	3.3	8.0	0.0	0.4	30.0	68.1	1.9
Rotation	17.0	5.2	5.5	0.0	0.2	28.0	62.7	9.4

TABLE 2. Mean Herbage Production in Pounds per Acre, Dickinson Experiment Station, July, 1987

RANGE SITE Treatment	Cool Season	Warm Season	Sedge	Forb	Shrub	Total Live	Standing Dead	Total Above Ground Herbage	Litter
SANDY									
Ungrazed									
Nongrazed	172	740	331	42	0	1285	482	1767	7434
Seasonlong	243	568	532	181	0	1524	603	2127	4446
Rotation	446	339	473	173	2	1432	362	1794	5487
Grazed									
Seasonlong	266	387	508	245	1	1406	566	1972	3227
Rotation	294	293	423	145	4	1158	365	1523	3783
SHALLOW									
Ungrazed									
Nongrazed	206	108	723	150	0	1187	376	1562	7172
Seasonlong	473	280	404	146	0	1302	224	1526	3139
Rotation	572	282	261	206	0	1320	499	1819	1922
Grazed									
Seasonlong	334	239	403	157	0	1132	205	1338	2967
Rotation	430	253	251	181	2	1118	235	1353	2278
SILTY									
Ungrazed									
Nongrazed	608	204	374	193	8	1388	429	1817	7161
Seasonlong	676	478	113	404	0	1671	663	2334	3140
Rotation	775	514	234	307	2	1832	299	2131	2131
Grazed									
Seasonlong	540	507	256	148	0	1452	395	1847	2168
Rotation	405	350	247	191	0	1193	244	1438	1675

TABLE 3. Mean Cow and Calf Periodic Weight in Pounds, Dickinson Experiment Station, 1987

Treatment	1 May	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	15 Sep	1 Oct	15 Oct	30 Oct	15 Dec
Seasonlong			Native										
Rotation	Crested					Native						Altai	
COW													
Seasonlong			1202		1256		1239		1309	1264		1231	
Rotation	1064	1104	1136	1179		1173		1180		1216	1200		1162
CALF													
Seasonlong			299		377		461		529	581		602	
Rotation	189	245	282	320		386		465		542	575		606*

*Calf wean date 12 Nov.

TABLE 4. Mean Cow and Calf Average Daily Gain and Gain per Acre in Pounds, Dickinson Experiment Station, 1987

	Crested Wheatgrass	Native Range	Altai Wildrye
Average Daily Gain (ADG)			
COW			
Seasonlong	-----	0.23	-----
Rotation	1.20	0.71	-0.56
CALF			
Seasonlong	-----	2.35	-----
Rotation	1.82	2.43	1.12
Gain/Acre (G/A)			
Cow			
Seasonlong	-----	3.5	-----
Rotation	52.7	10.5	-32.8
Calf			
Seasonlong	-----	35.4	-----
Rotation	80.2	36.2	27.2

Appendix

for

Project No. 1786

Grazing Effects on the Structure

and Dynamics of Grassland Ecosystems

Table 1. Grazing Dates, Stocking Pressure and Cow and Calf Gain per Acre for Crested Wheatgrass Pastures at the Dickinson Experiment Station

Treatment Year	Number Head	Acres	Acre Per ead	Dates	Number Days	Number Months	AUM Per Acre	Gain per Acre Cow	Calf
Unfertilized, Main Station:									
1978	10	16	1.6	22 May – 19 Jun	28	0.92	0.58	34.4	29.7
1979	10	16	1.6	22 May – 22 Jun	31	1.02	0.64	41.9	36.3
1980	7	16	2.3	23 Jun – 07 Jul	14	0.46	0.20	- 8.4	13.1
1981	8	16	2.0	22 May – 24 Jun	33	1.08	0.54	5.3	34.7
1982	10	16	1.6	20 May – 21 Jun	32	1.05	0.66	66.9	40.6
$\bar{x}$								28.0	30.9
Fertilized, Main Station:									
1978	10	8	0.8	15 May – 10 Jul	56	1.84	2.30	135.0	129.1
1979	10	8	0.8	22 May – 22 Jun	31	1.02	1.28	110.7	101.4
1980	7	8	1.1	23 Jun – 07 Jul	14	0.46	0.40	- 12.5	22.0
1981	8	8	1.0	15 May – 17 Jun	33	1.08	1.08	32.0	73.3
1982	10	8	0.8	20 May – 21 Jun	32	1.05	1.31	156.2	86.4
$\bar{x}$								84.3	82.4
Fertilized, Ranch Headquarters:									
1983	16	13	0.8	11 May – 10 Jun	30	0.98	1.21	97.9	65.0
1984	20	13	0.7	10 May – 01 Jun	22	0.72	1.11	105.3	72.4
1985	24	13	0.5	06 May – 29 May	23	0.75	1.29	93.4	79.8
1986	26	13	0.5	13 May – 30 May	17	0.56	1.12	144.7	79.5
1987	26	13	0.5	05 May – 27 May	22	0.72	1.44	52.7	80.2
$\bar{x}$								98.8	75.4

Table 2. Grazing Dates, Stocking Pressure and Cow and Calf Gain per Acre Data for Native Range Pastures at the Dickinson Experiment Station

Treatment Year	Number Head	Acres	Acre Per Head	Dates	Number Days	Number Months	AUM Per Acre	Gain per Acre Cow	Gain per Acre Calf
Unfertilized, Main Station:									
1978	10	18	1.8	19 Jun – 14 Aug	56	1.84	1.02	13.4	55.2
1979	10	18	1.8	22 Jun – 20 Jul	28	0.92	0.51	23.8	31.9
1980	7	18	2.6	07 Jul – 23 Jul	16	0.52	0.20	0.3	12.5
1981	8	18	2.3	24 Jun – 28 Jul	35	1.15	0.51	5.6	27.5
1982	10	18	1.8	21 Jun – 20 Aug	60	1.97	1.09	20.7	65.2
$\bar{x}$								12.8	38.5
Fertilized, Main Station:									
1978	10	12	1.2	10 Jul – 15 Sep	67	2.20	1.83	-48.9	68.1
1979	10	12	1.2	22 Jun – 20 Jul	28	0.92	0.77	16.2	32.5
1980	7	12	1.7	07 Jul – 23 Jul	16	0.52	0.30	- 5.9	15.4
1981	8	12	1.5	17 Jun – 04 Aug	49	1.61	1.07	1.7	49.6
1982	10	12	1.2	21 Jun – 20 Aug	60	1.97	1.64	25.0	95.8
$\bar{x}$								- 2.4	52.3
Alfalfa Interseeded, Main Station:									
1978	10	10	1.0	19 Jun – 07 Aug	49	1.61	1.61	72.2	113.6
1979	10	10	1.0	22 Jun – 20 Jul	28	0.92	0.92	61.9	60.5
1980	7	10	1.4	07 Jul – 16 Jul	9	0.30	0.21	-34.5	6.5
1981	8	10	1.3	24 Jun – 21 Jul	28	0.92	0.74	-34.2	43.1
1982	0	10							
$\bar{x}$								16.4	55.9

Table 2 (Continued):

Treatment Year	Number Head	Acres	Acre Per Head	Dates	Number Days	Number Months	AUM Per Acre	Gain per Acre Cow	Gain per Acre Calf
Seasonlong, Breed Efficiency, Ranch Headquarters:									
A+H, Baldie:									
1986	8	91	11.4	11 Jul - 23 Oct	104	3.41	0.30	5.1	19.9
1987	10	91	9.1	19 Jun - 26 Oct	129	4.23	0.46	2.6	32.3
H+H, Hereford:									
1986	7	80	11.4	11 Jul – 23 Oct	104	3.41	0.30	5.2	19.0
1987	10	80	8.0	19 Jun – 26 Oct	129	4.23	0.53	6.5	34.9
MSH, Shorthorn:									
1986	8	80	10.0	11 Jul – 23 Oct	104	3.41	0.34	5.7	24.1
1987	10	80	8.0	19 Jun – 26 Oct	129	4.23	0.53	1.6	41.9
$\bar{x}$								4.5	28.7
Seasonlong, Ranch Headquarters:									
1983	20	320	16.0	17 Jun – 26 Oct	131	4.30	0.27	8.5	17.8
1984	25	320	12.8	26 Jun – 05 Nov	132	4.33	0.34	0.8	18.8
1985	25	320	12.8	18 Jun – 22 Oct	126	4.13	0.32	0.7	21.3
1986	25	320	12.8	20 Jun – 07 Nov	140	4.59	0.36	1.7	24.3
1987	35	320	9.1	09 Jun – 27 Oct	140	4.59	0.50	10.3	38.7
$\bar{x}$								4.4	24.2
Short Duration, Ranch Headquarters:									
1983	35	320	9.1	17 Jun – 26 Oct	131	4.30	0.47	10.1	30.3
1984	35	320	9.1	26 Jun – 05 Nov	132	4.33	0.47	0.6	26.7
1985	35	320	9.1	18 Jun – 22 Oct	126	4.13	0.45	1.8	28.3
1986	35	320	9.1	20 Jun – 07 Nov	140	4.59	0.50	1.6	33.1
1987	35	320	9.1	09 Jun – 27 Oct	140	4.59	0.50	10.8	37.3
$\bar{x}$								5.0	31.1

Table 2 (Continued):

Treatment Year	Number Head	Acres	Acre Per Head	Dates	Number Days	Number Months	AUM Per Acre	Gain per Acre Cow	Gain per Acre Calf
Twice Over Rotation, Ranch Headquarters:									
1983	16	235	14.7	10 Jun – 20 Oct	132	4.33	0.29	7.4	19.9
1984	19	235	12.4	01 Jun – 16 Oct	137	4.49	0.36	2.8	21.7
1985	24	235	9.8	29 May – 18 Oct	143	4.69	0.48	7.3	28.9
1986	26	235	9.0	30 May – 17 Oct	141	4.62	0.51	12.0	35.2
1987	26	235	9.0	01 Jun – 15 Oct	136	4.46	0.49	10.5	36.2
x								8.0	28.4

Table 3. Average Daily Gain by Biweekly Periods for Cows Grazing Crested Wheatgrass Pastures at the Dickinson Experiment Station

Treatment Year	1-15 May	16-31 May	1-15 Jun	16-30 Jun	1-15 Jul	$\bar{x}$
Complementary, Main Station:						
1978-1979, 1981-1982						
Unfertilized		1.95	1.95	1.95		1.95
Fertilized		2.62	2.54	2.21	1.11	2.12
1980, Drought						
Unfertilized				-1.37	-1.37	-1.37
Fertilized				-1.02	-1.02	-1.02
Complementary, Ranch Headquarters:						
Fertilized:						
1983	2.65	2.65	2.65			2.65
1984	3.11	3.11				3.11
1985	2.20	2.20				2.20
1986	4.26	4.26				4.26
1987	1.18	1.18				1.18
$\bar{x}$	2.68	2.68	2.65			2.68

Table 4. Average Daily Gain by Biweekly Periods for Calves Grazing Crested Wheatgrass Pastures at the Dickinson Experiment Station

Treatment Year	1-15 May	16-31 May	1-15 Jun	16-30 Jun	1-15 Jul	$\bar{x}$
Complementary, Main Station:						
1978-1979, 1981-1982						
Unfertilized		1.91	1.91	1.91		1.91
Fertilized		2.18	2.18	2.24	1.96	2.14
1980, Drought						
Unfertilized				2.25	2.25	2.25
Fertilized				1.79	1.79	1.79
Complementary, Ranch Headquarters:						
Fertilized:						
1983	1.76	1.76	1.76			1.76
1984	2.14	2.14				2.14
1985	1.88	1.88				1.88
1986	2.34	2.34				2.34
1987	1.82	1.82				1.82
$\bar{x}$	1.99	1.99	1.76			1.99

Table 5. Average Daily Gain by Biweekly Periods for Cows Grazing Native Range Pastures at the Dickinson Experiment Station

Treatment Year	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	$\bar{x}$
Complementary, Main Station:											
1978-1979, 1981-1982											
Unfertilized		1.23	1.23	0.18	0.25	-0.25					0.53
Fertilized		1.23	1.27	0.25	-0.88	-1.79	-2.52				-0.49
Alfalfa, Interseeded		0.80	0.80	0.64	1.17						0.85
1980, Drought:											
Unfertilized			0.04	0.04							0.04
Fertilized			-0.63	-0.63							-0.63
Alfalfa Interseeded			-5.48								-5.48
Seasonlong, Breed Efficiency, Ranch Headquarters:											
A+H, Baldie:											
1986			1.90	1.90	1.90	1.00	-0.50	-0.50	-0.50	-0.24	0.62
1987		2.23	2.23	-1.30	-1.30	3.52	4.21	-3.48	-1.18	-0.03	0.08
H+H, Hereford:											
1986			0.97	0.97	0.97	0.75	0.38	0.38	0.38	-0.65	0.52
1987		2.04	2.04	-0.95	-0.95	2.47	1.92	0.37	-0.88	-1.51	0.51
MSH, Shorthorn:											
1986			0.82	0.82	0.82	0.72	0.55	0.55	0.55	-1.30	0.44
1987		1.28	1.28	0.61	0.61	1.81	0.67	-1.30	-2.52	-3.13	-0.08
$\bar{x}$		1.85	1.54	0.34	0.34	1.71	1.21	-0.66	-0.69	-1.14	0.35

Table 5 (Continued):

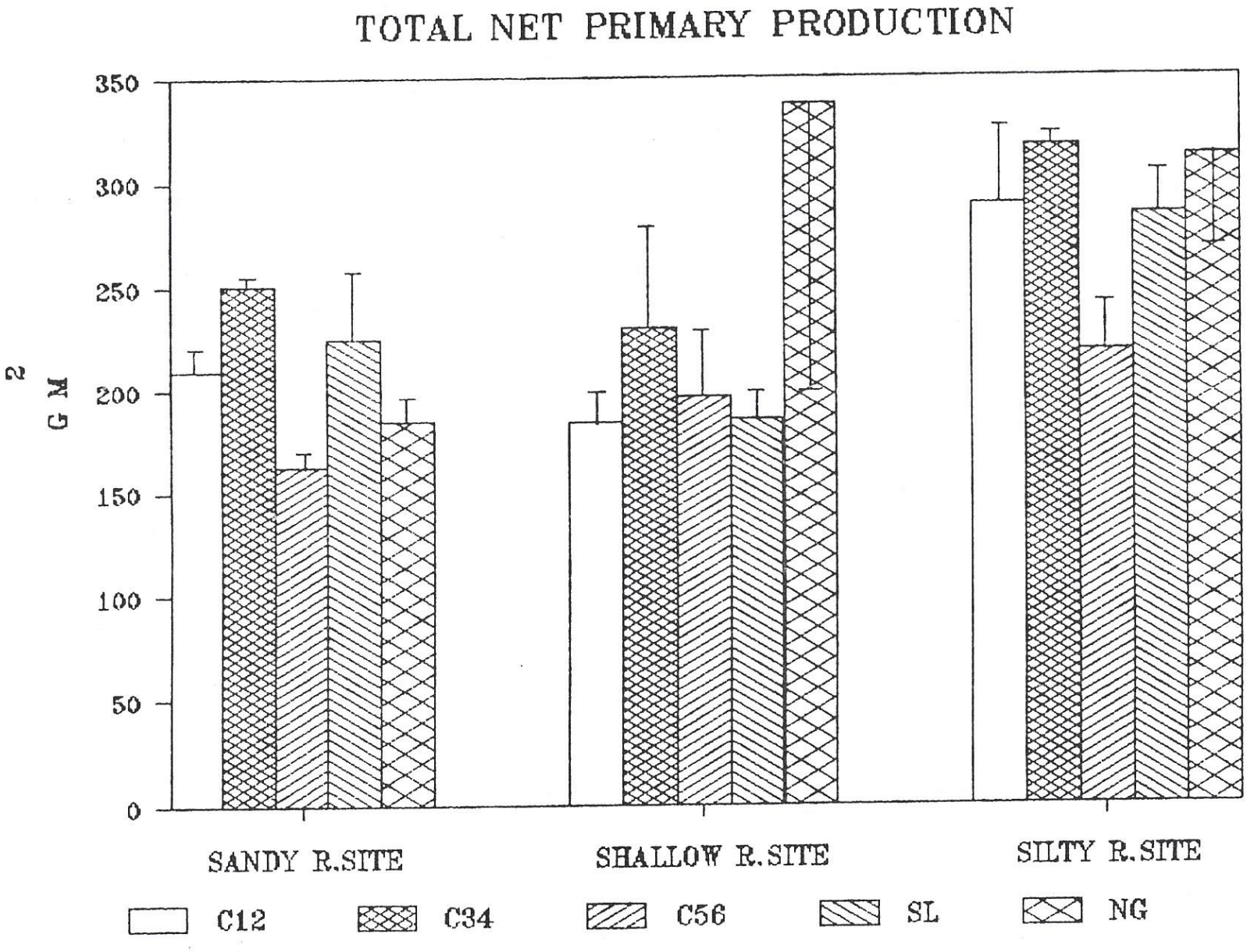
Treatment Year	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	$\bar{x}$
Seasonlong, Ranch Headquarters:											
1983		2.53	2.53	1.38	1.32	1.08	0.50	-0.36	-0.24	0.56	1.03
1984		2.50	2.50	1.89	0.86	0.11	-0.48	-1.35	-1.66	-1.42	0.33
1985		1.49	1.49	0.29	0.13	-0.18	-0.38	-0.78	-0.78	-0.78	0.06
1986		1.43	1.43	1.84	1.94	-0.63	-0.60	-0.48	-0.80	-1.45	0.30
1987		1.88	0.94	0.11	0.49	0.63	1.29	1.08	-0.59	-0.59	0.58
$\bar{x}$		1.97	1.78	1.10	0.95	0.20	0.07	-0.38	-0.81	-0.74	0.46
Short Duration, Ranch Headquarters:											
1983		2.66	2.66	-0.99	-0.63	0.79	0.61	0.35	0.41	0.81	0.74
1984		0.92	0.92	0.78	0.71	0.34	0.05	-0.79	-1.11	-0.66	0.13
1985		2.25	2.25	-0.13	-0.03	0.38	-0.18	-1.29	-1.29	-1.29	0.07
1986		2.17	2.17	0.83	0.64	-0.01	-0.34	-1.68	-1.33	-0.62	0.20
1987		2.89	1.11	-0.44	0.33	0.61	1.47	1.18	-1.08	-1.08	0.55
$\bar{x}$		2.18	1.82	0.01	0.20	0.42	0.32	-0.45	-0.88	-0.57	0.34
Twice Over Rotation, Ranch Headquarters:											
1983	2.17	2.17	1.40	1.01	0.12	0.45	1.87	1.10	-1.12		1.02
1984	1.52	1.97	0.45	0.45	0.10	0.13	0.43	0.43	-3.35		0.24
1985	3.85	0.63	0.63	0.66	0.88	0.70	-0.60	-0.60	-0.80		0.59
1986	4.25	1.53	0.94	0.91	2.02	1.60	-1.38	-1.38	-1.44		0.78
1987	3.41	4.53	0.08	-0.45	0.82	1.59	3.88	3.14	-1.68		1.70
$\bar{x}$	3.04	2.17	0.70	0.52	0.79	0.89	0.84	0.54	-1.68		0.87

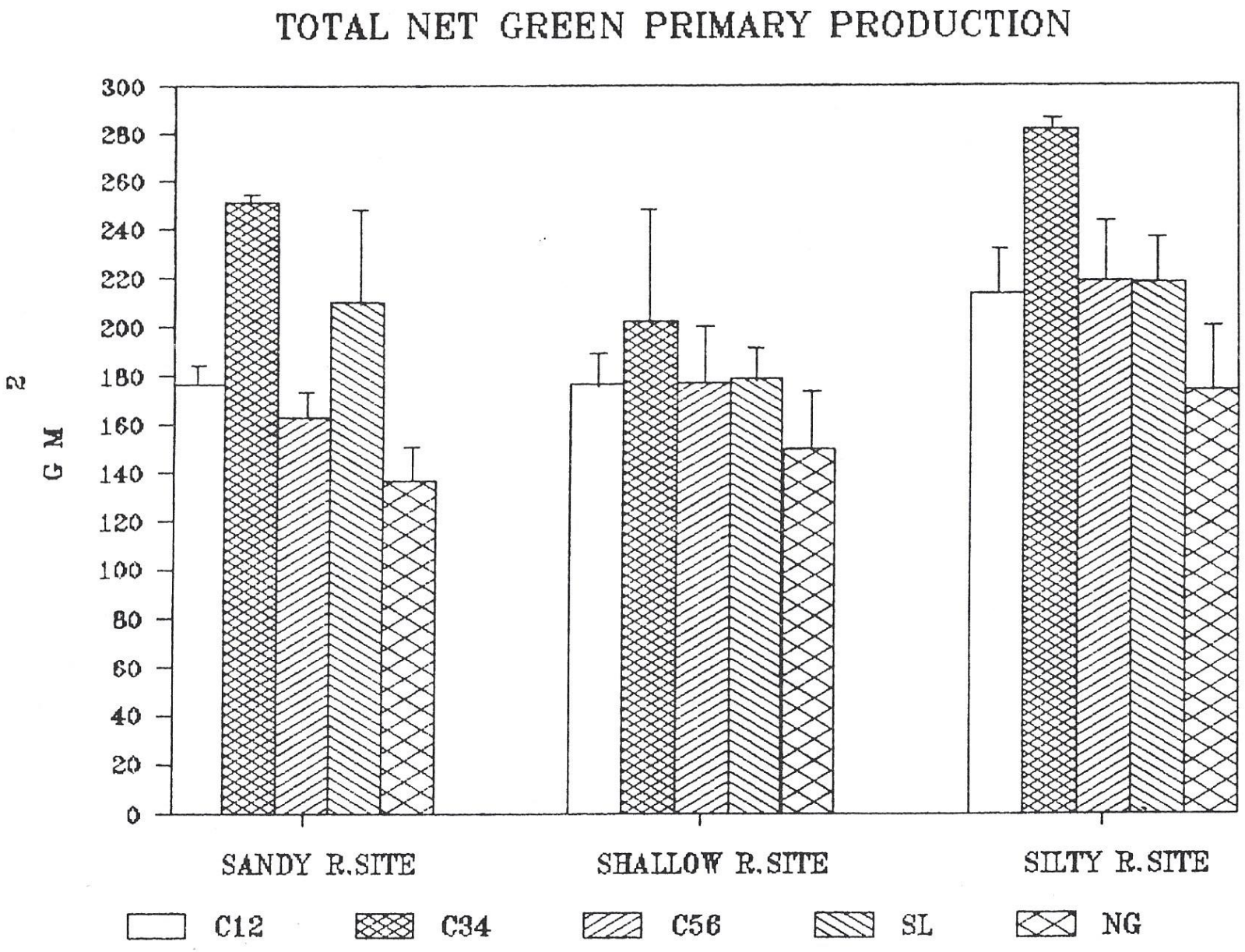
Table 6. Average Daily Gain by Biweekly Periods for Calves Grazing Native Range Pastures at the Dickinson Experiment Station

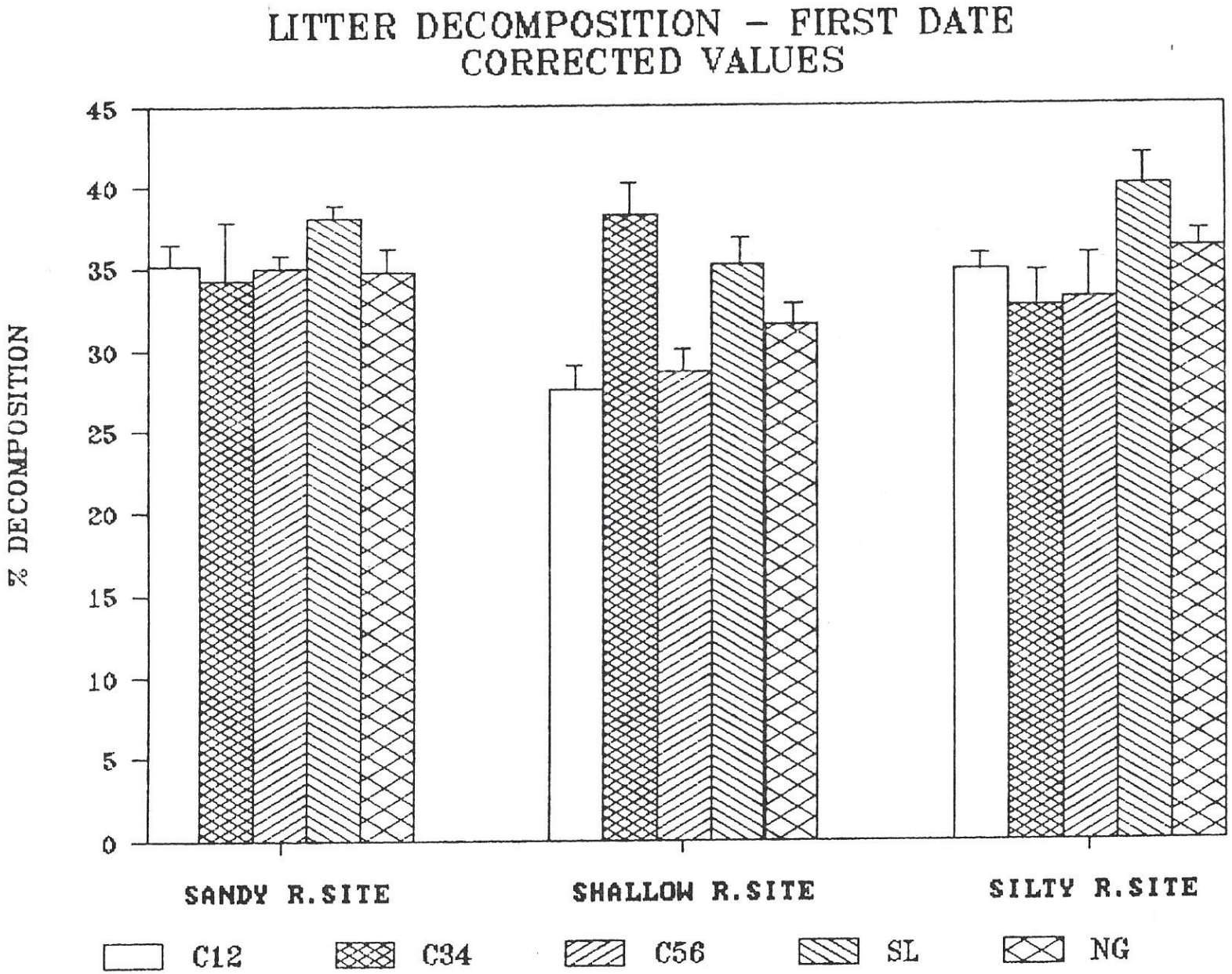
Treatment Year	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	$\bar{x}$
Complementary, Main Station:											
1978-1979, 1981-1982											
Unfertilized		1.91	1.91	1.89	1.90	1.77					1.88
Fertilized		1.79	1.91	1.72	1.42	0.96	0.46				1.38
Alfalfa Interseeded		1.95	1.95	2.32	3.05						2.32
1980, Drought											
Unfertilized			2.01	2.01							2.01
Fertilized			1.65	1.65							1.65
Alfalfa Interseeded			1.03								1.03
Seasonlong, Breed Efficiency, Ranch Headquarters:											
A+H, Baldie											
1986			2.86	2.86	2.86	2.36	1.72	1.72	1.72	1.14	2.16
1987		2.99	2.99	2.49	2.49	3.11	2.48	1.66	1.49	1.43	2.35
H+H, Hereford											
1986			2.59	2.59	2.59	2.28	1.89	1.89	1.89	0.24	2.00
1987		2.62	2.62	2.47	2.47	2.61	2.37	2.08	1.03	0.65	2.10
MSH, Shorthorn											
1986			2.74	2.74	2.74	2.54	2.20	2.20	2.20	0.33	2.21
1987		2.23	2.23	2.90	2.90	2.97	2.81	2.56	1.65	1.20	2.38
$\bar{x}$		2.61	2.67	2.68	2.68	2.65	2.25	2.02	1.66	0.83	2.20

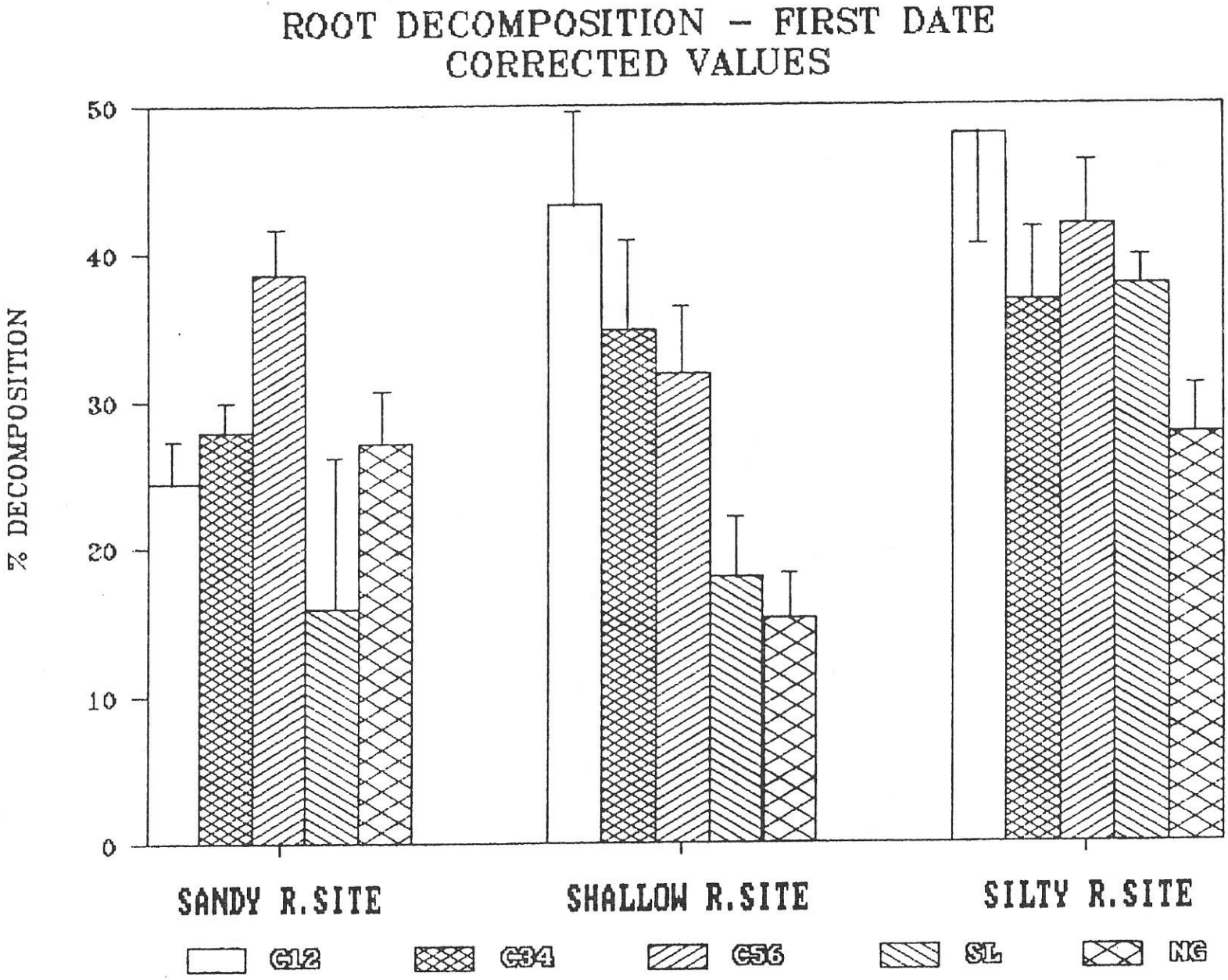
Table 6 (Continued):

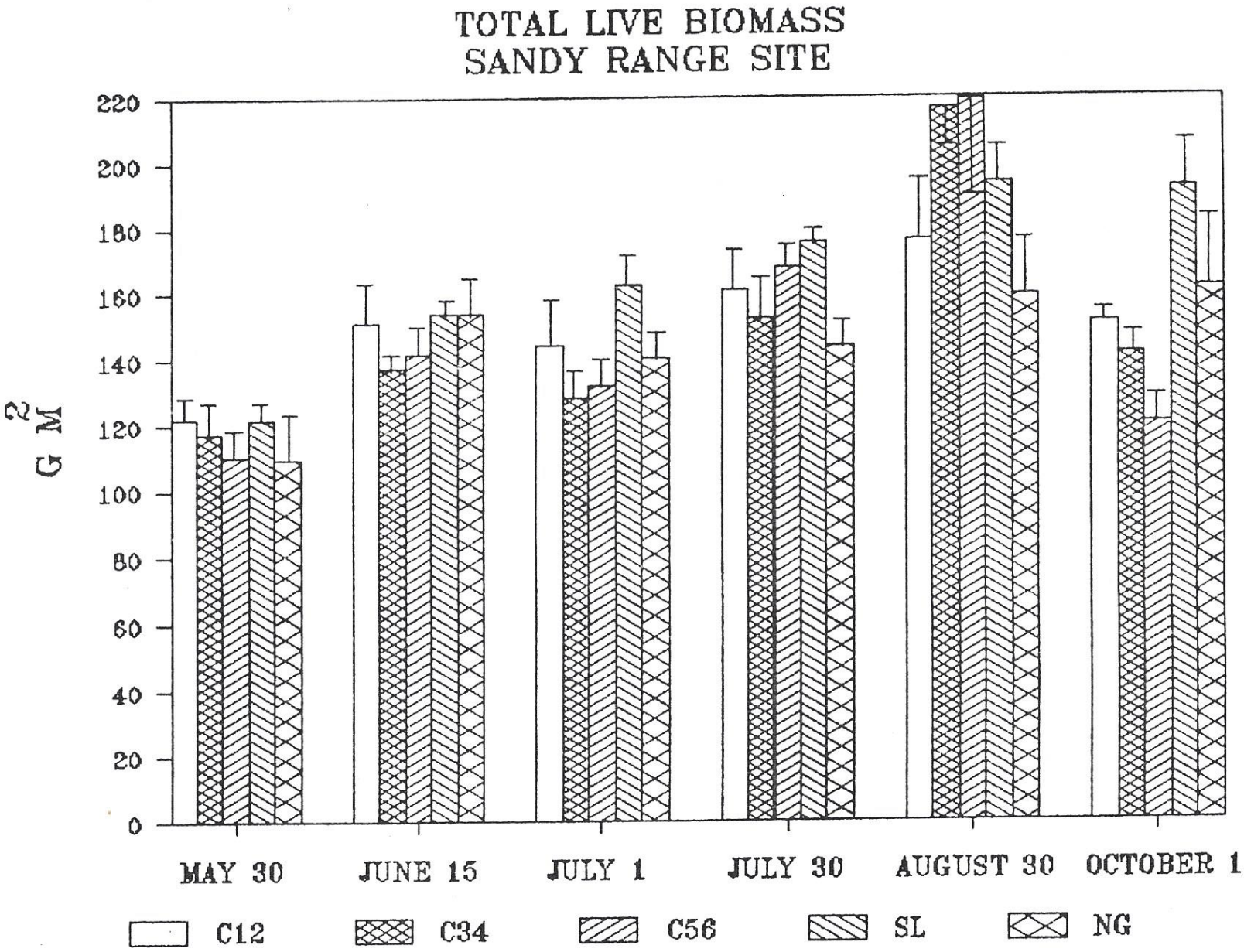
Treatment Year	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	16-30 Sep	1-15 Oct	16-31 Oct	$\bar{x}$
Seasonlong, Ranch Headquarters:											
1983		2.28	2.28	2.45	2.38	2.18	2.11	2.03	1.90	1.54	2.13
1984		2.32	2.32	2.41	2.52	2.23	2.06	1.22	1.01	0.87	1.88
1985		2.65	2.65	1.00	1.38	2.41	2.07	1.55	1.55	1.55	1.87
1986		2.74	2.74	2.76	2.77	2.72	2.50	1.89	1.52	0.97	2.29
1987		2.63	2.53	2.47	2.63	2.67	2.77	2.68	2.09	2.09	2.51
$\bar{x}$		2.52	2.50	2.22	2.34	2.44	2.30	1.87	1.61	1.40	2.14
Short Duration, Ranch Headquarters:											
1983		2.46	2.46	2.18	2.19	2.25	2.07	1.81	1.78	1.58	2.09
1984		2.27	2.27	2.29	2.33	2.30	2.27	1.07	0.77	1.38	1.88
1985		2.42	2.42	2.35	2.37	2.48	2.10	1.33	1.33	1.33	2.01
1986		2.71	2.71	2.78	2.79	2.62	2.40	1.53	1.40	1.15	2.23
1987		2.46	2.51	2.56	2.87	2.98	2.64	2.50	1.56	1.56	2.40
$\bar{x}$		2.46	2.47	2.43	2.51	2.53	2.30	1.65	1.37	1.40	2.12
Twice Over Rotation, Ranch Headquarters:											
1983	2.30	2.30	2.31	2.31	2.27	2.33	2.59	2.10	1.68		2.24
1984	2.82	1.51	2.09	2.09	2.27	2.27	1.93	1.93	1.07		2.00
1985	2.46	2.07	2.11	2.16	2.48	2.42	1.96	1.96	1.25		2.10
1986	3.14	1.92	2.37	2.37	3.00	2.80	1.94	1.94	1.24		2.30
1987	2.35	2.52	2.38	2.40	2.71	2.66	2.49	2.38	1.94		2.43
$\bar{x}$	2.61	2.06	2.25	2.27	2.55	2.50	2.18	2.06	1.44		2.21

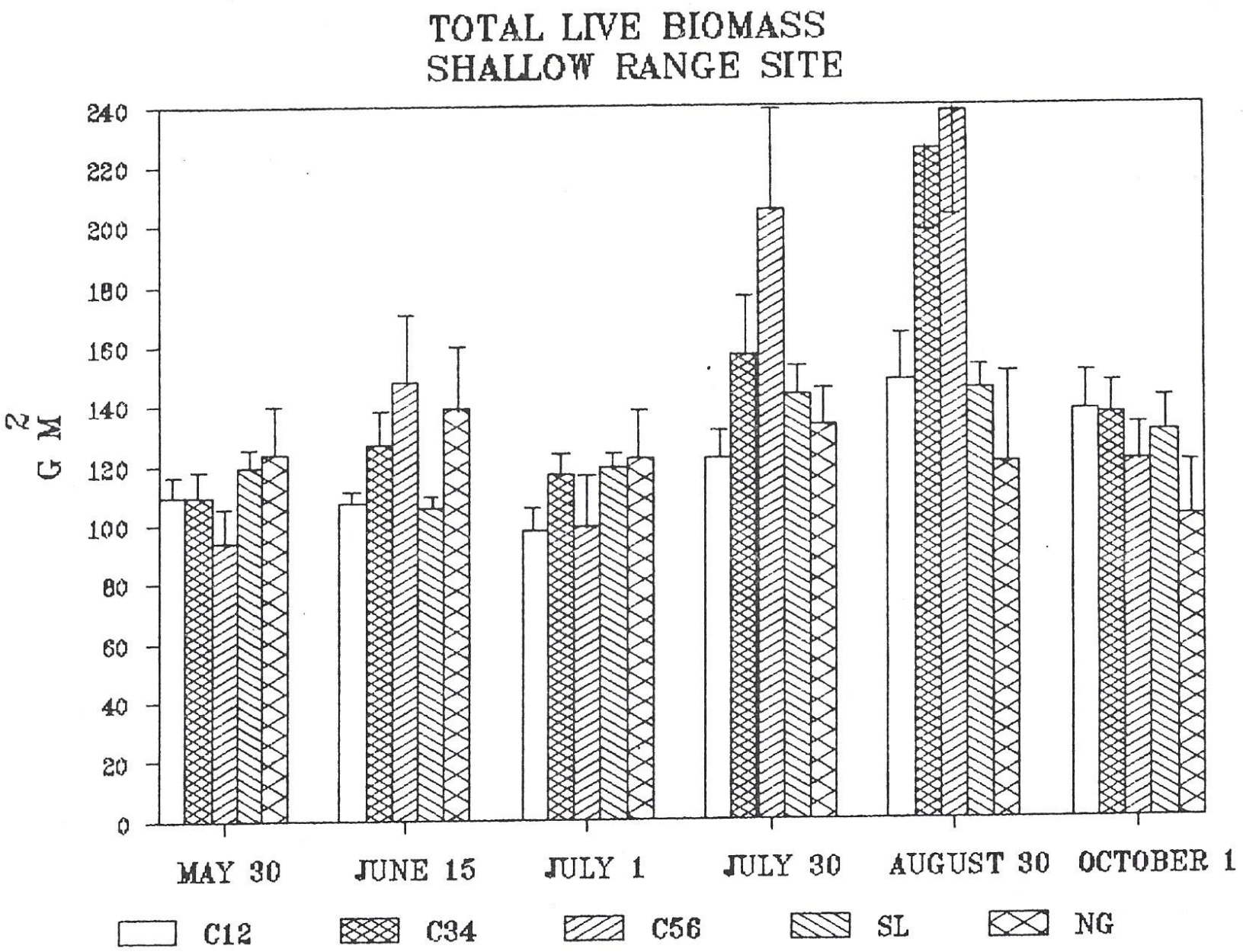

TOTAL NET PRIMARY PRODUCTION
G M 2
350
300
250
200
150
100
50
0
SANDY R.SITE
SHALLOW R.SITE
SILTY R.SITE
C12
C34
C56
SL
NG

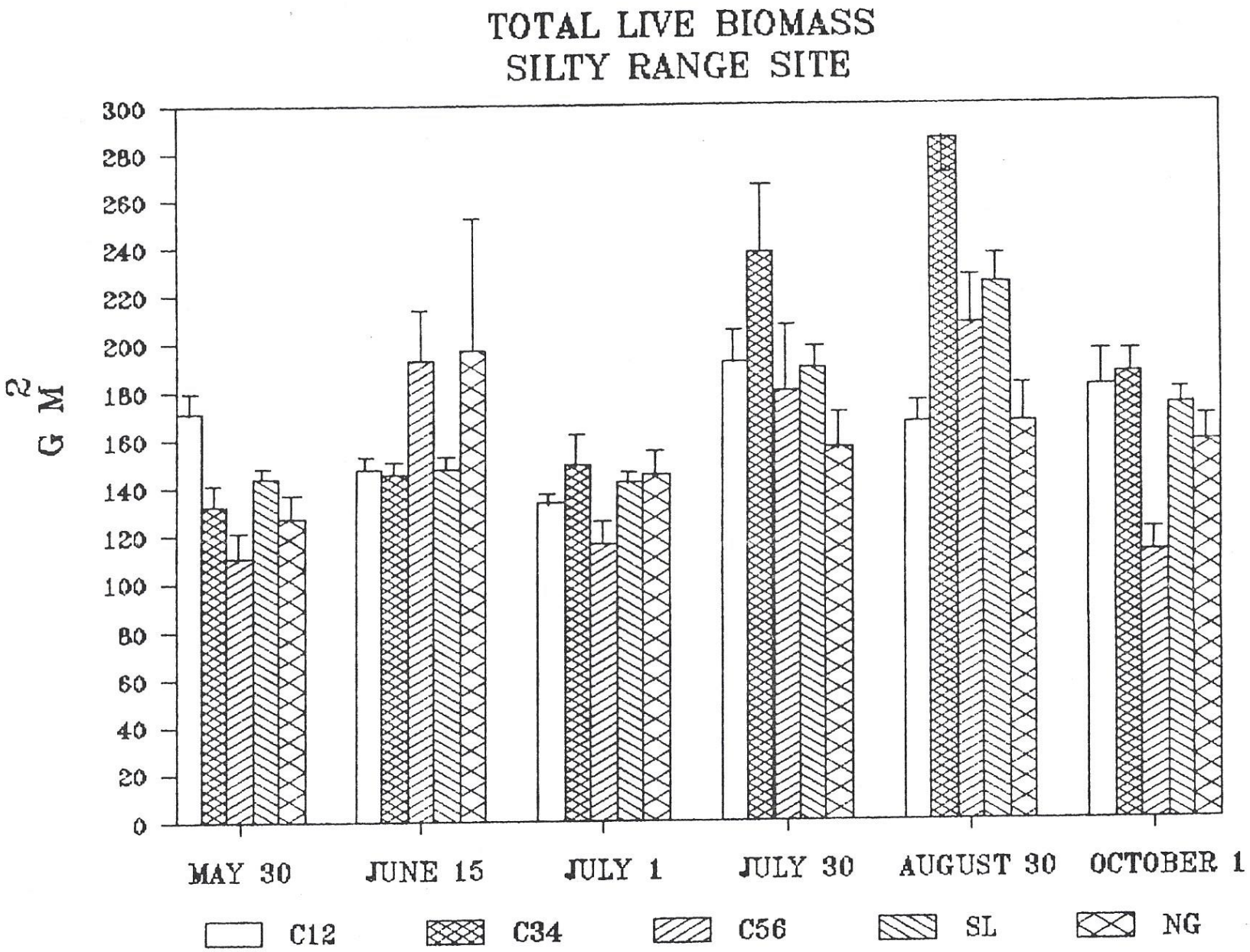

TOTAL NET GREEN PRIMARY PRODUCTION
G M 2
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
SANDY R.SITE
SHALLOW R.SITE
SILTY R.SITE
C12
C34
C56
SL
NG

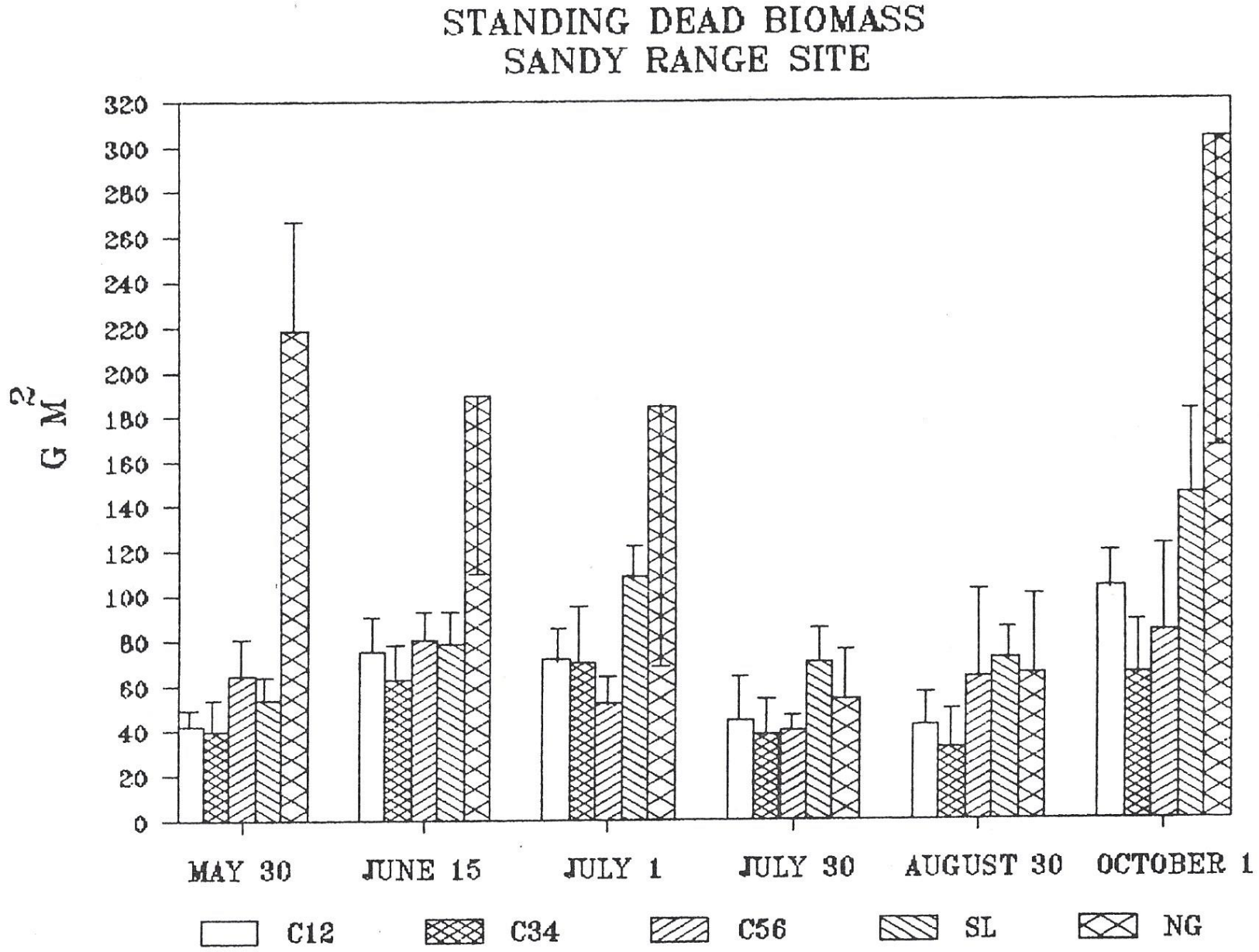

LITTER DECOMPOSITION – FIRST DATE
CORRECTED VALUES
% DECOMPOSITION
45
40
35
30
25
20
15
10
5
0
SANDY R.SITE
SHALLOW R.SITE
SILTY R.SITE
C12
C34
C56
SL
NG

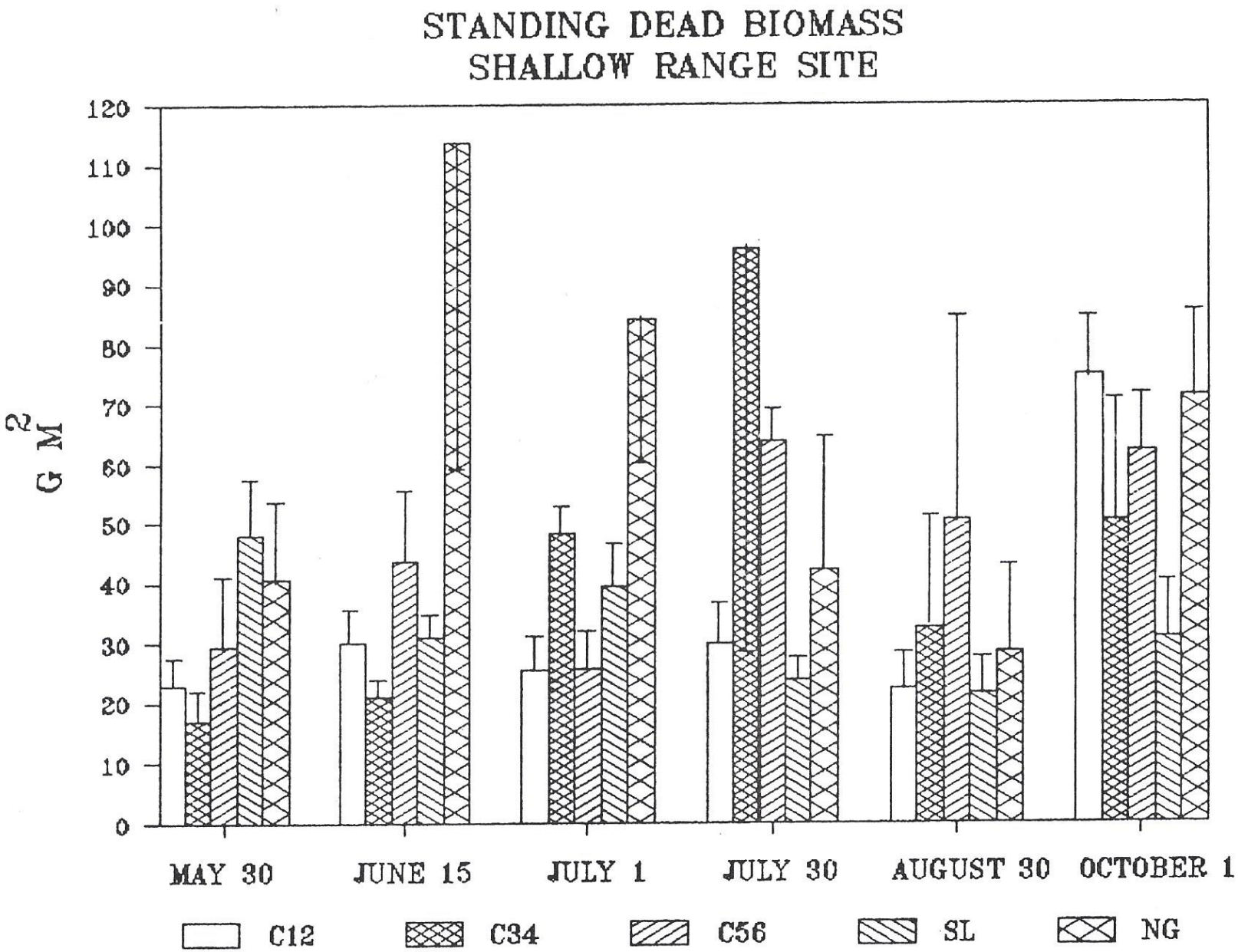

ROOT DECOMPOSITION – FIRST DATE
CORRECTED VALUES
% DECOMPOSITION
50
40
30
20
10
0
SANDY R.SITE
SHALLOW R.SITE
SILTY R.SITE
G12
G34
G56
SL
NG

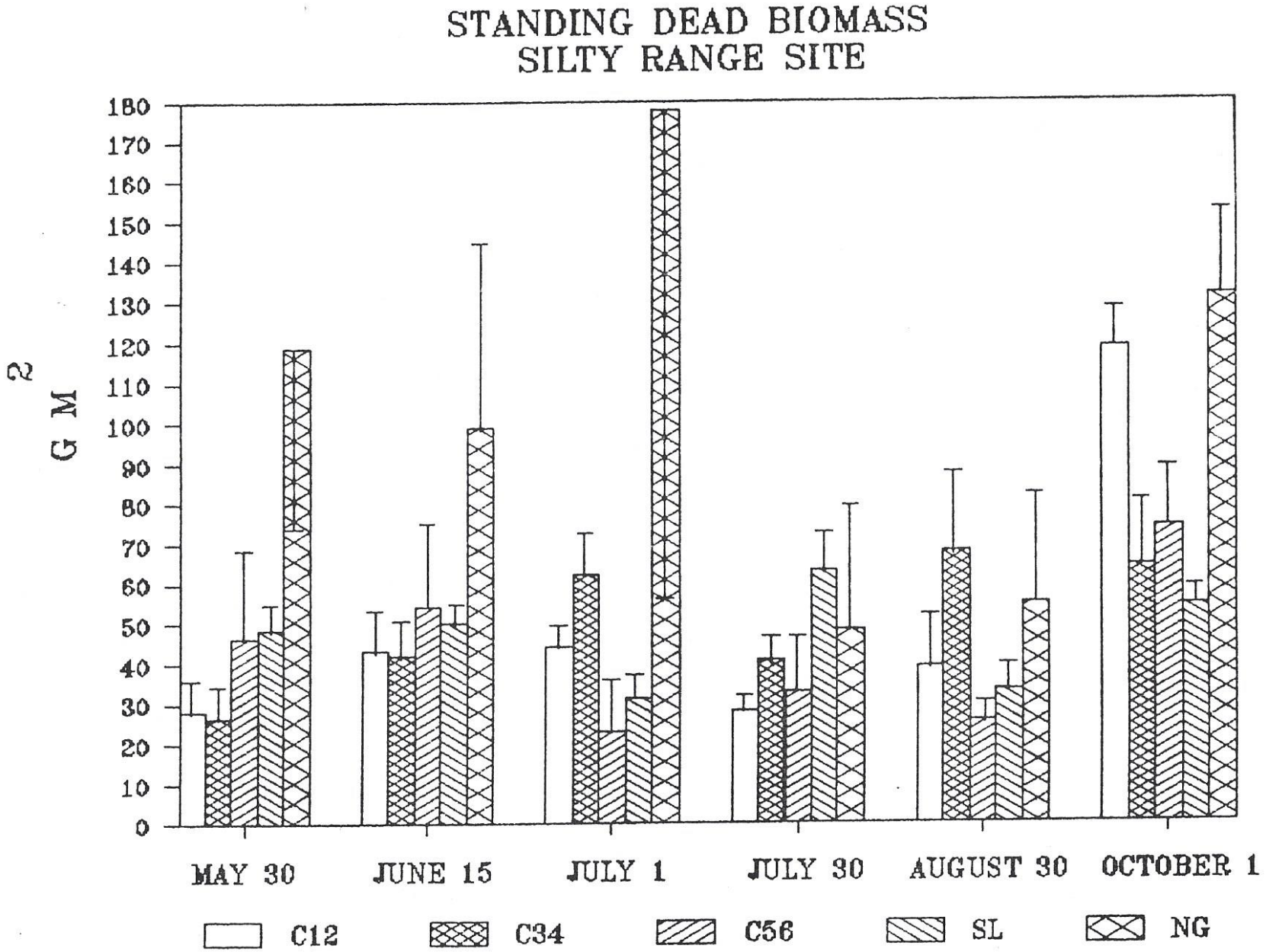

TOTAL LIVE BIOMASS
SANDY RANGE SITE
G M 2
220
200
180
160
140
120
100
80
60
40
20
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

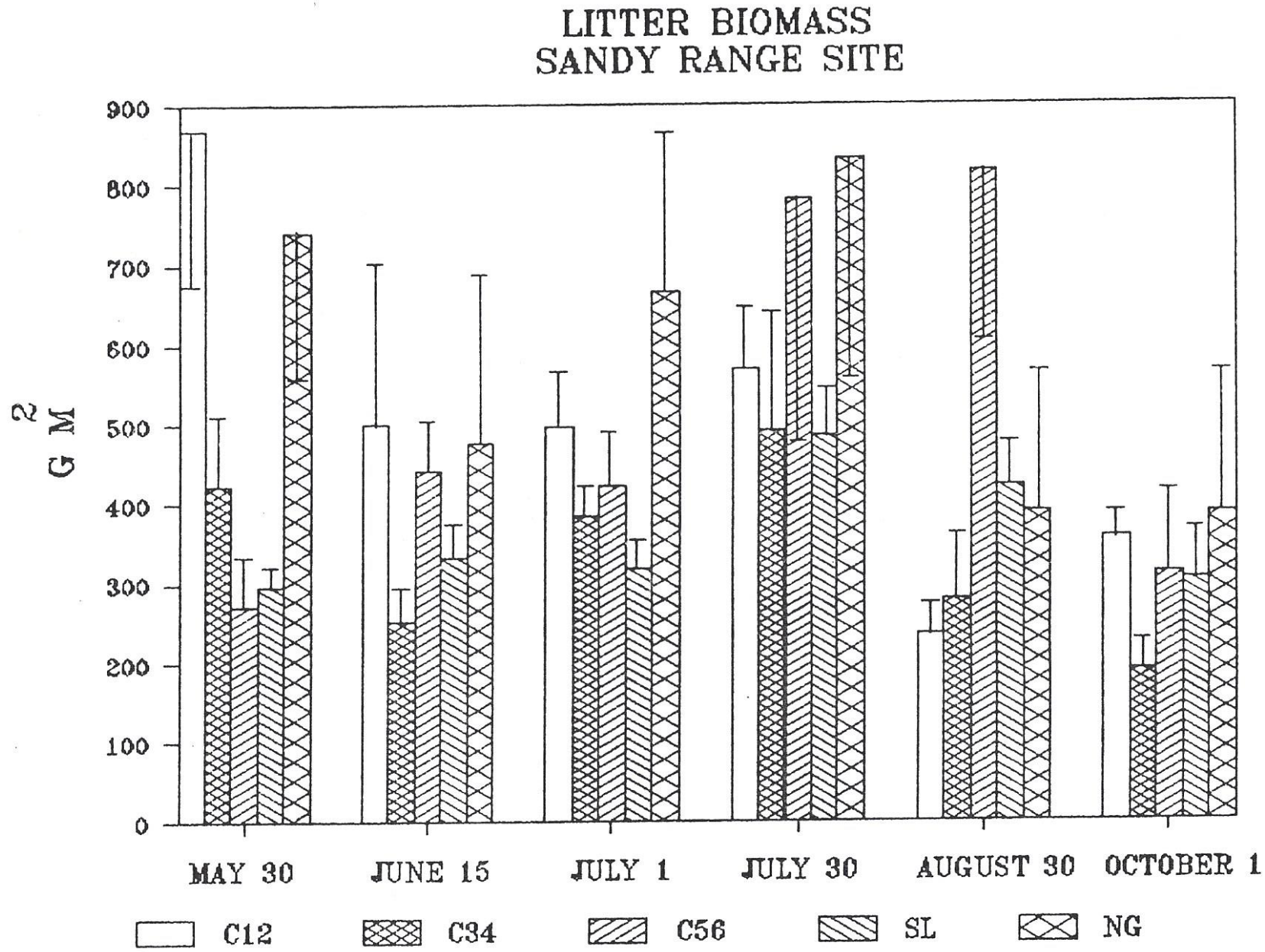

TOTAL LIVE BIOMASS
SHALLOW RANGE SITE
G M 2
240
220
200
180
160
140
120
100
80
60
40
20
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

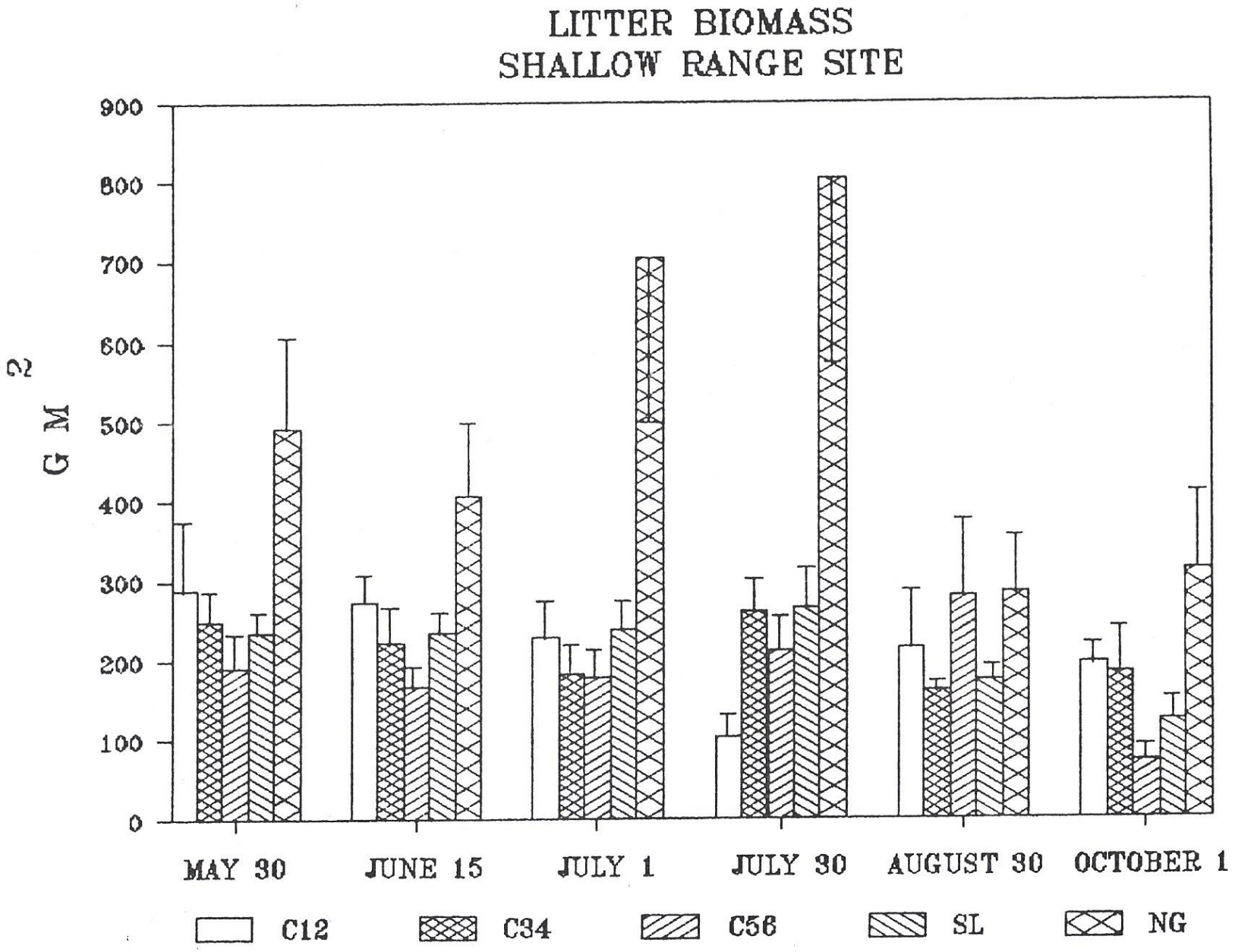

TOTAL LIVE BIOMASS
SILTY RANGE SITE
G M 2
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

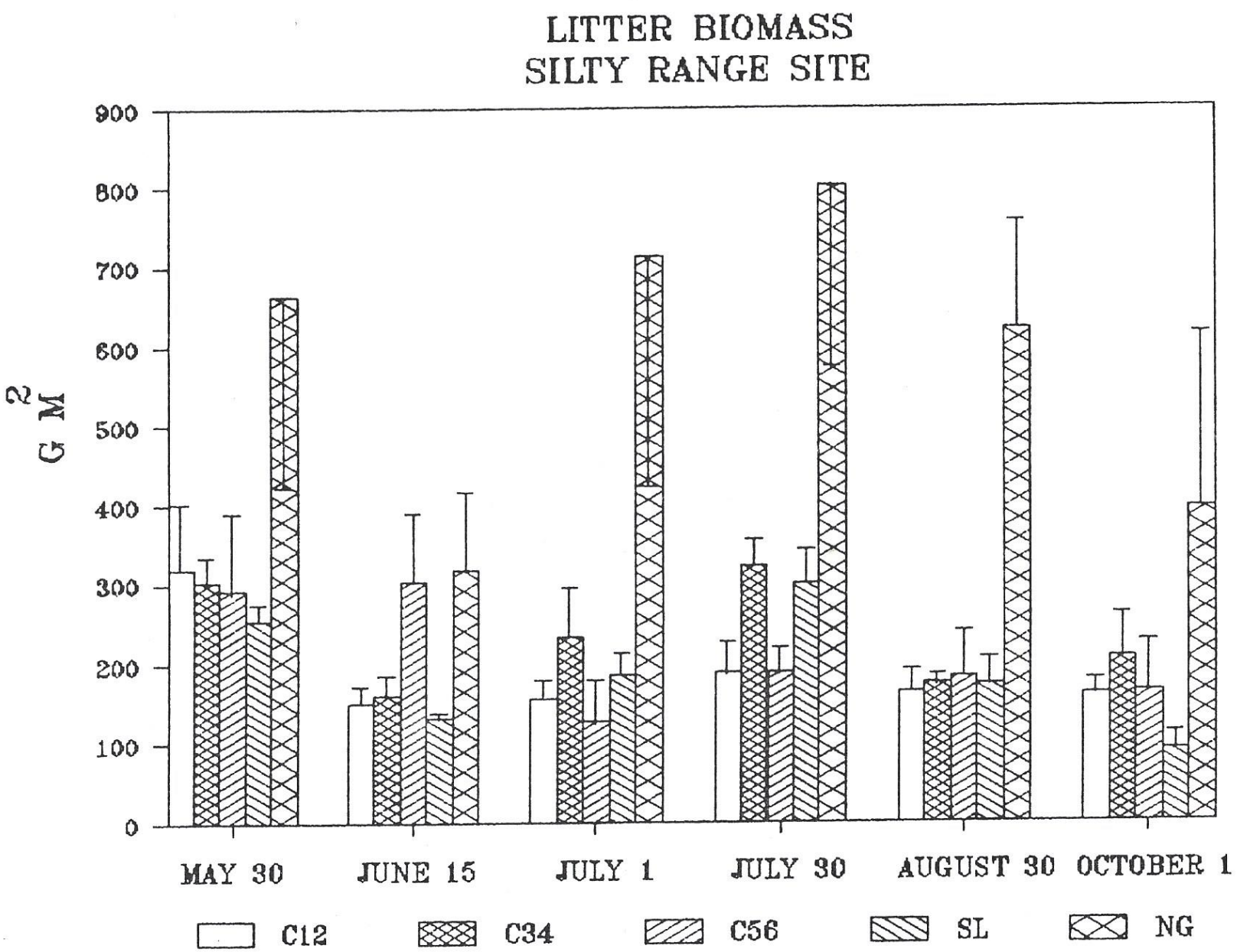

STANDING DEAD BIOMASS
SANDY RANGE SITE
G M 2
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

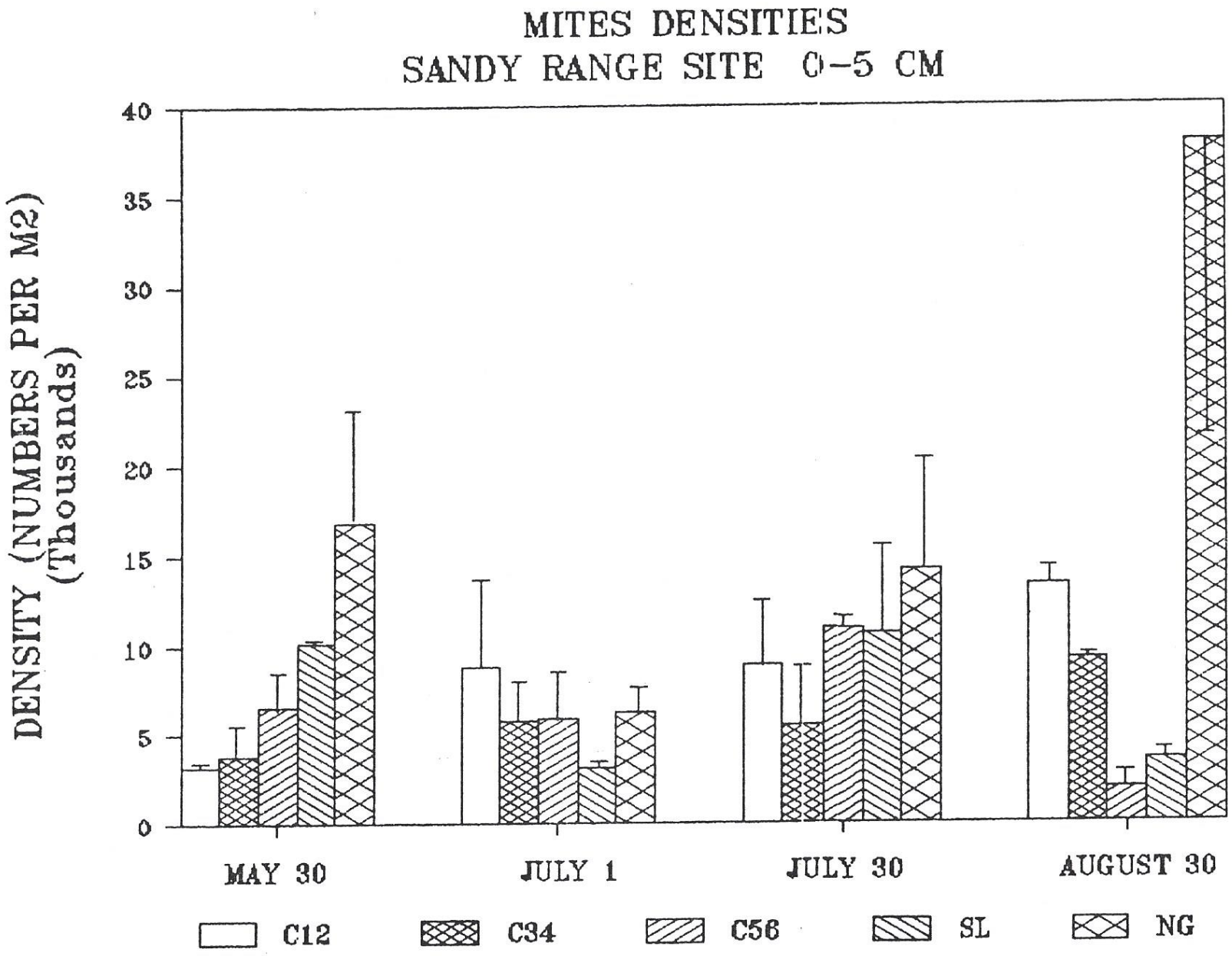

STANDING DEAD BIOMASS
SHALLOW RANGE SITE
G M 2
120
110
100
90
80
70
60
50
40
30
20
10
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

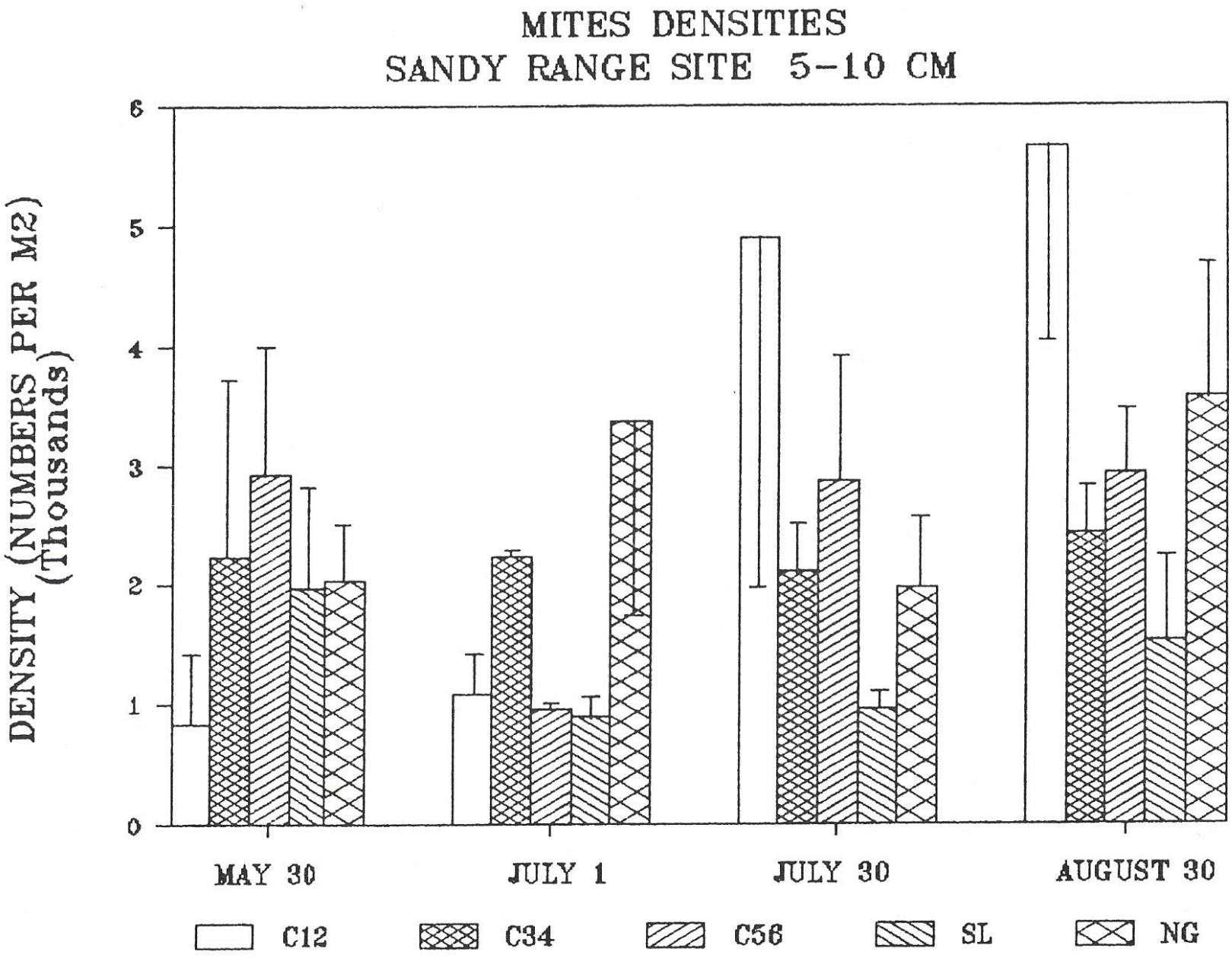

STANDING DEAD BIOMASS
SILTY RANGE SITE
G M 2
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

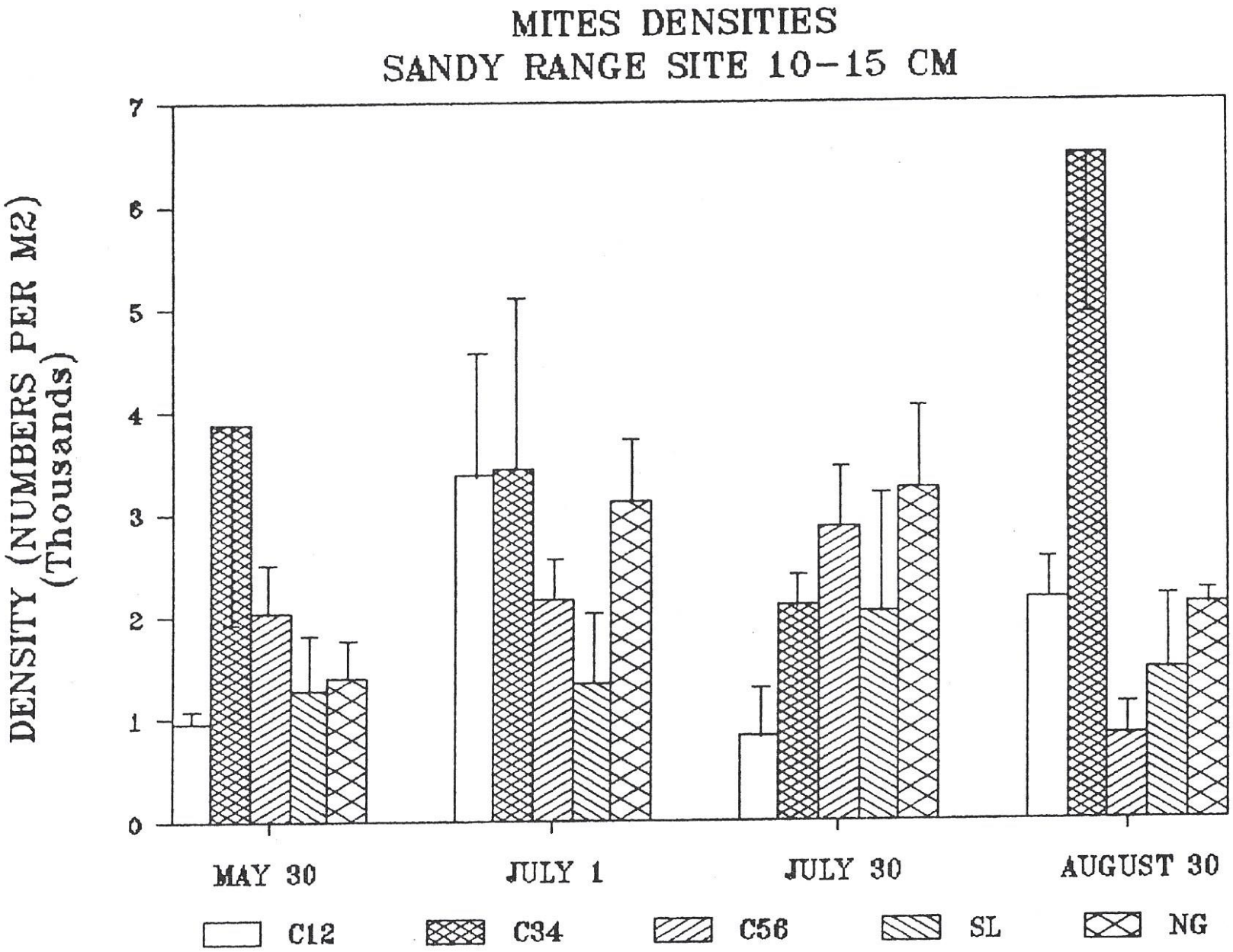

LITTER BIOMASS
SANDY RANGE SITE
G M 2
900
800
700
600
500
400
300
200
100
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

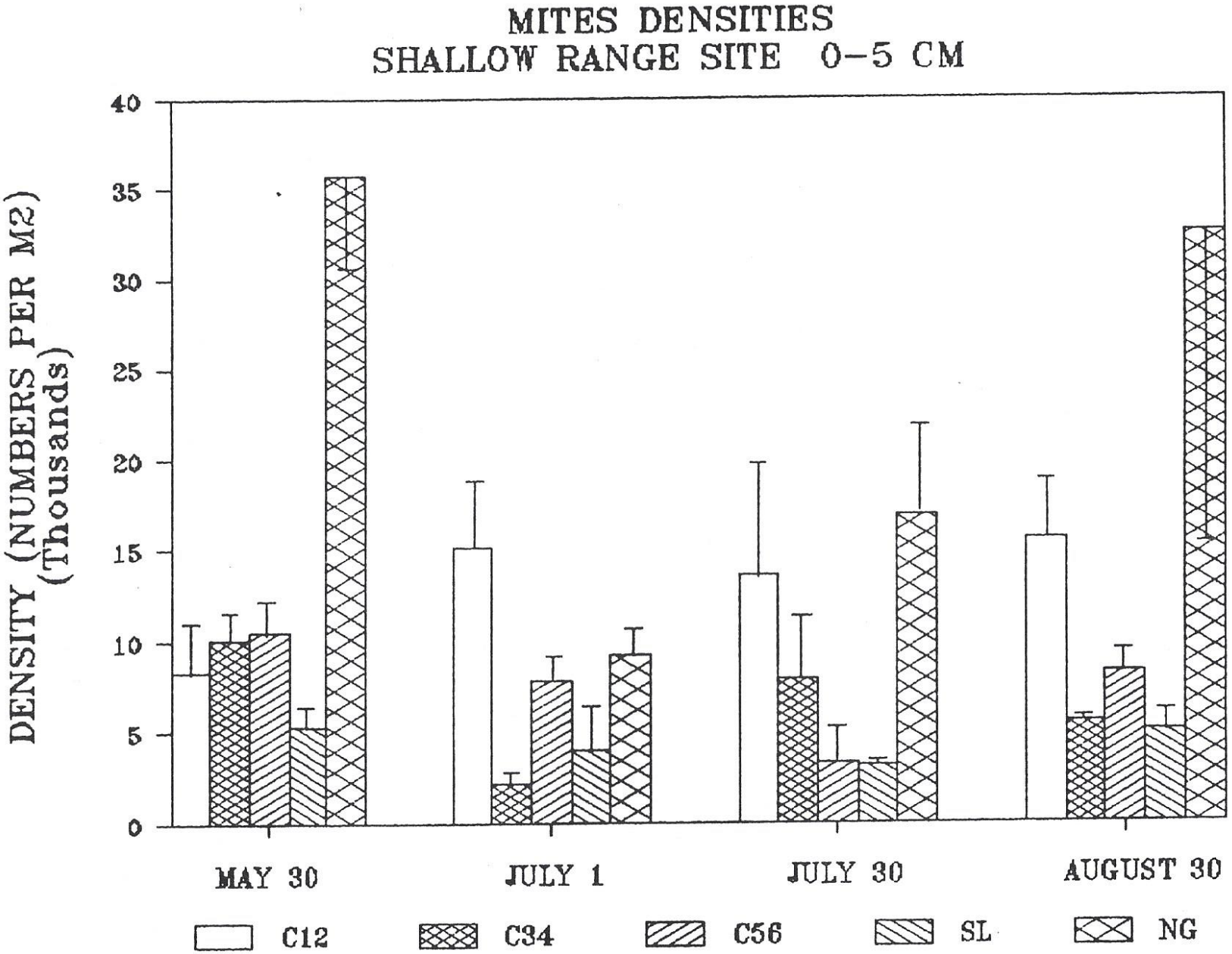

LITTER BIOMASS
SHALLOW RANGE SITE
G M 2
900
800
700
600
500
400
300
200
100
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

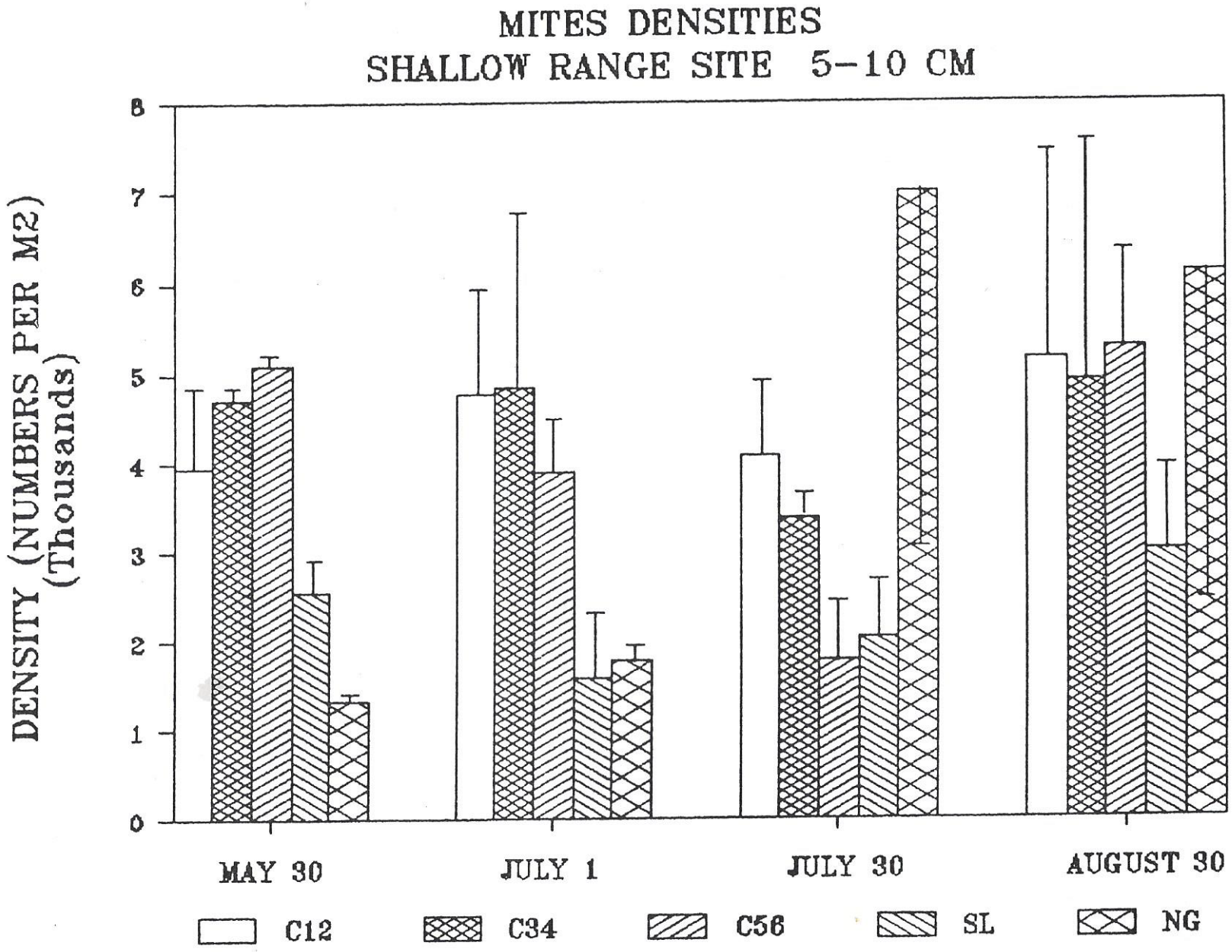

LITTER BIOMASS
SILTY RANGE SITE
G M 2
900
800
700
600
500
400
300
200
100
0
MAY 30
JUNE 15
JULY 1
JULY 30
AUGUST 30
OCTOBER 1
C12
C34
C56
SL
NG

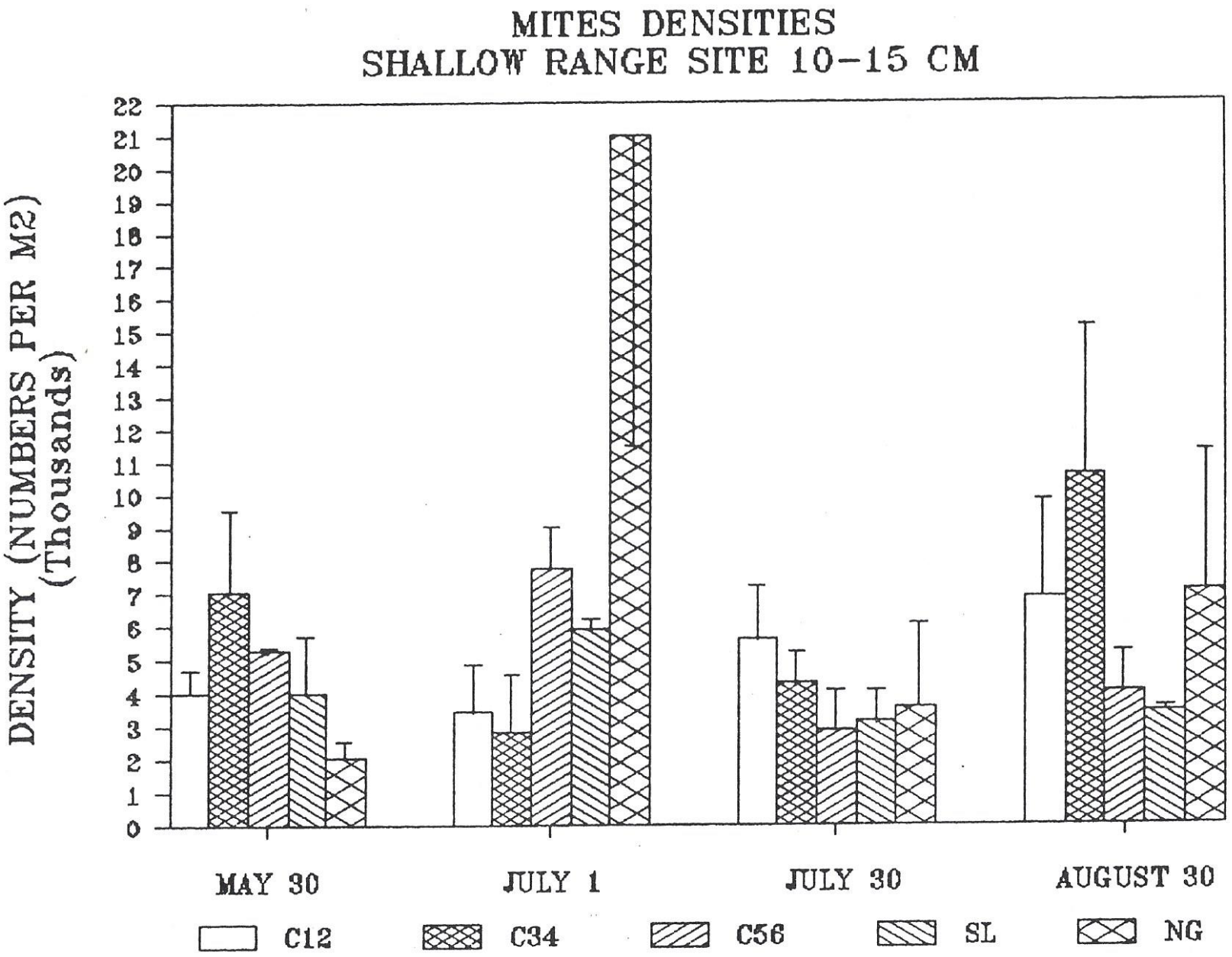

MITES DENSITIES
SANDY RANGE SITE 0-5 CM
DENSITY (NUMBERS PER M2)
(Thousands)
40
35
30
25
20
15
10
5
0
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG

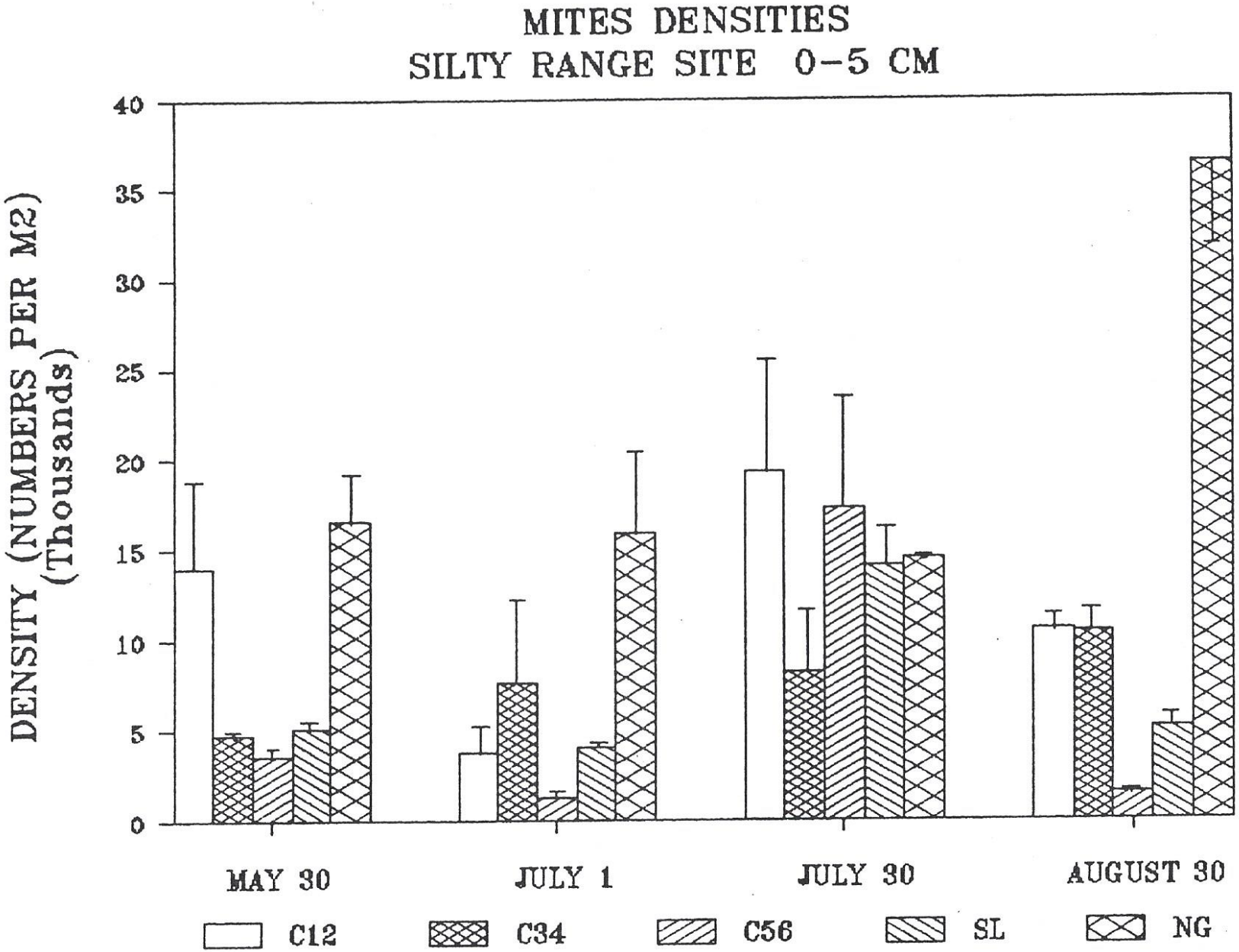

MITES DENSITIES
SANDY RANGE SITE 5-10 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG

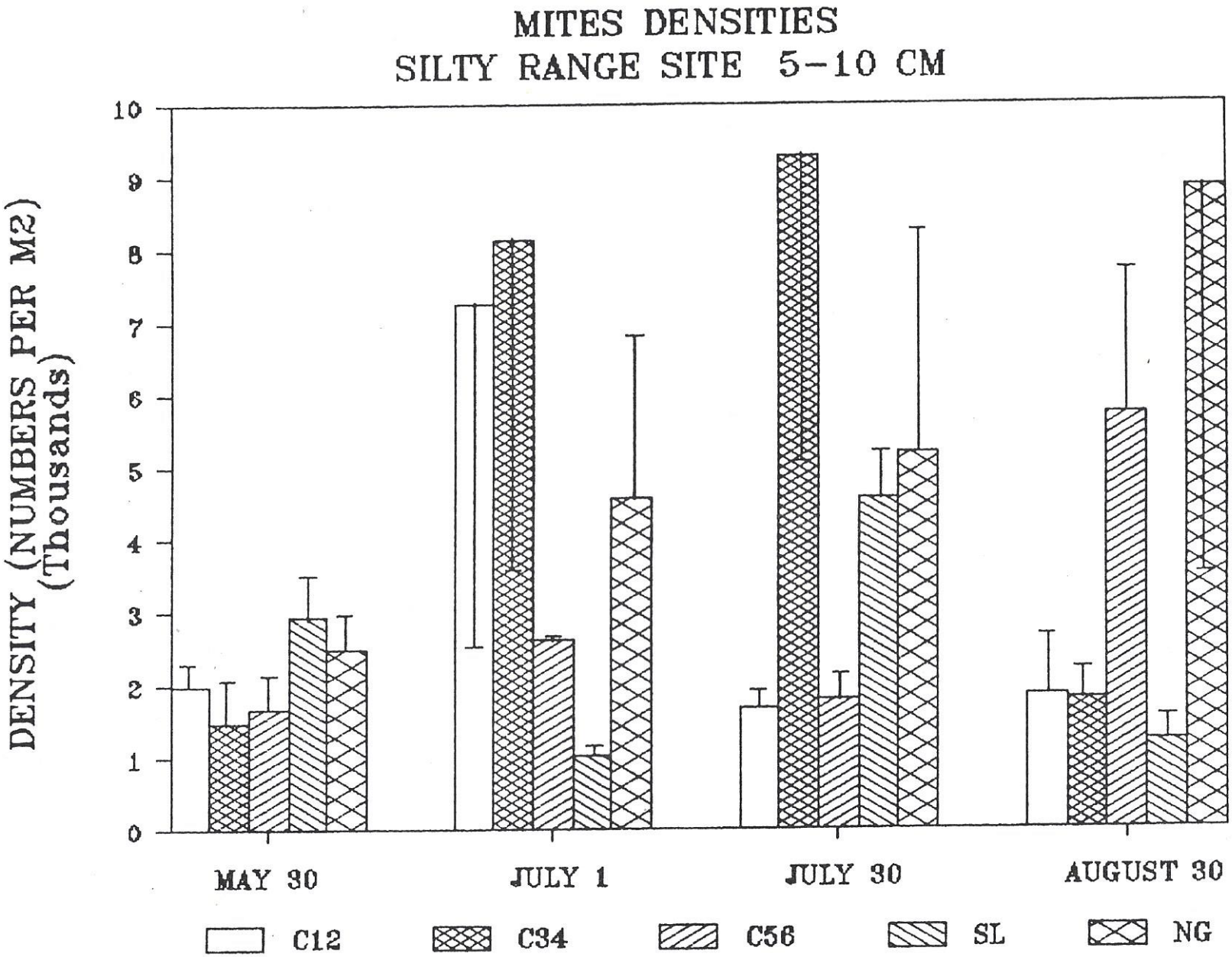

MITES DENSITIES
SANDY RANGE SITE 10-15 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
7
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG

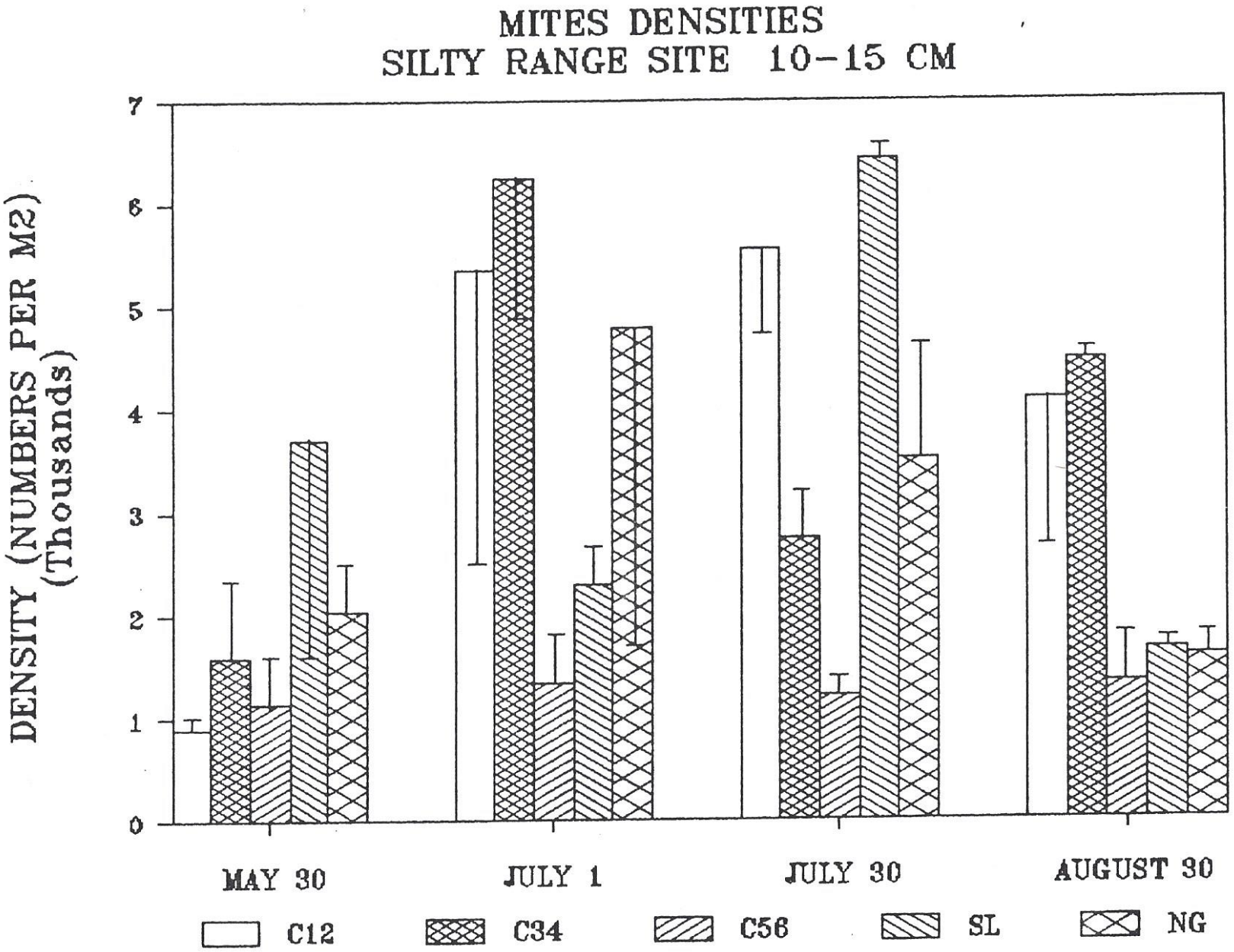

MITES DENSITIES
SHALLOW RANGE SITE 0-5 CM
DENSITY (NUMBERS PER M2)
(Thousands)
40
35
30
25
20
15
10
5
0
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG


MITES DENSITIES
SHALLOW RANGE SITE 5-10 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
7
8
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG


MITES DENSITIES
SHALLOW RANGE SITE 10-15 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG


MITES DENSITIES
SILTY RANGE SITE 0-5 CM
DENSITY (NUMBERS PER M2)
(Thousands)
40
35
30
25
20
15
10
5
0
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG


MITES DENSITIES
SILTY RANGE SITE 5-10 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG


MITES DENSITIES
SILTY RANGE SITE 10-15 CM
DENSITY (NUMBERS PER M2)
(Thousands)
0
1
2
3
4
5
6
7
MAY 30
JULY 1
JULY 30
AUGUST 30
C12
C34
C56
SL
NG