CHAPTER 5

RESEARCH SUMMARY AND CONCLUSIONS

Much of the variation in this species is genetic (Chapter 2), and therefore, mesquitegrass appears to have great potential to be improved for use as a low maintenance turfgrass and soil stabilizing ground cover. Breeding procedures that capitalize on additive genetic variation should allow for progress in important turfgrass traits. The results of the Cultural Practices Experiment (Chapter 3) demonstrate that mesquitegrass can perform well (display acceptable color, high ground cover, and good uniformity) under turfgrass management practices. Lastly, it is now known that this species can be established by seeding (Chapter 4), and good ground cover can be achieved in one season at low seeding rates.

It seems likely that this grass would be accepted as a home lawn or golf course rough turf. A major genetic breakthrough would be needed to take this species to 'fairway' turf, such that this circumstance seems unlikely. Many factors will influence the success of this species as a turfgrass, with the two major factors being a) physical and political water use pressures and b) continued funding and financial support.
APPENDIX A

METHODOLOGY FOR DETERMINING THE STANDARD ERRORS FOR THE COMPONENTS OF VARIANCE

The components and mathematical procedures for determining the standard error of a component of variance are outlined as described by Wricke and Weber (1986).

<table>
<thead>
<tr>
<th>source</th>
<th>d.f.</th>
<th>m.s.</th>
<th>E(m.s.)</th>
<th>variance component</th>
</tr>
</thead>
<tbody>
<tr>
<td>genotypes</td>
<td>( f_1 = g - 1 )</td>
<td>( m_1 )</td>
<td>( \sigma^2 + r(\sigma_{t}^2 + \sigma_{w}^2) )</td>
<td>( s_{t}^2 = (m_1 - m_3) / r )</td>
</tr>
<tr>
<td>blocks</td>
<td>( f_2 = r - 1 )</td>
<td>( m_2 )</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>error</td>
<td>( f_3 = f_1 \cdot f_2 )</td>
<td>( m_3 )</td>
<td>( \sigma^2 )</td>
<td>( s^2 = m_3 )</td>
</tr>
</tbody>
</table>

The variance of a mean square \((m_i)\) is determined by

\[
V(m_i) = 2[E(m_i)]^2/f_i = 2m_i^2/(f_i + 2)
\]

Therefore, the variances for the mean squares of genotypes and error \((V(s_{t}^2)\) and \(V(s^2)\), respectively) are

\[
V(s_{t}^2) = 2/r^2 \left[ (m_1^2/f_1 + 2) + (m_3^2/f_3 + 2) \right]
\]

and

\[
V(s^2) = 2m_3^2/(f_3 + 2)
\]

Standard errors then are determined by computing the square roots of \(V(s_{t}^2)\) and \(V(s^2)\) such that

\[
SE(s_{t}^2) = \left( 2/r^2 \left[ (m_1^2/f_1 + 2) + (m_3^2/f_3 + 2) \right] \right)^{1/2}
\]

and

\[
SE(s^2) = \left[ 2m_3^2/(f_3 + 2) \right]^{1/2}
\]
APPENDIX B

COLLECTION LOG: COLLECTIONS OF HILARIA BELANGERI IN ARIZONA

Most of the plant material described herein is not currently maintained as established plots of distinct identity. This appendix serves only as a guide to resecuring plant material identified as 'desirable' for some given characteristic. Accession numbers are given with the county of origin first, a brief description of the location, followed by the actual accession and plant sample number.

Accession

  1  Pima Co. Arivaca, AZ. Reference point (rp)=Marley Cattle Co. sign going to Arivaca on Arivaca Road.

    1-1  2.3 miles after rp, on right side of road. Heavily grazed area on open range, a large patch but not a totally thick sod. Good stolon formation.

    1-2  Actually collected from the Noon Ranch in Oro Blanco, AZ (sort of in between Ruby, and Arivaca, AZ). Cobbly soil. All 1-2 plants are clones from the sole survivor of the collection trip. Heavily grazed. No where near reference point.

    1-3  5.7 miles after rp on a steep short hill on the right side of the road. Good clinging ability.

    1-4  10 miles after rp on right side of road after a wash. Heavily grazed and trampled. Small thick patches.

    1-5  13.4 miles after rp on left side of road, on a cut off/steep small hill.
1-6 14.1 miles after rp. A giant patch on both sides of the road. The road is going around a big curve up a hill. A very solid stand, heavily grazed.

2  Santa Cruz Co. Sonoita, AZ (reference point is the junction of State Highways #82 & #83).

2-1 1 mile west of rp on #82 on the north side of road on one of the hills. Southern exposure.

2-2 1 more mile west on #82, (mile post 30) again on the north side of the road on a hill with southern exposure.

2-3 0.5 more miles west on #82. North side of road.

2-4 [North on #83. There is a telephone pole on the east side of #83 just after the junction of #82 & #83.]

0.3 miles north of #82 on #83, east side of the road under and all around the telephone pole. A rather extensive patch going over the fence into the field.

2-5 1 mile north of #82 on #83 on the east side of the road.

2-6 2.2 miles north of #82 on #83. On the east side of the road, up on the hill.

3  Santa Cruz Co. Patagonia, AZ.

3-1 Go through Patagonia. After the 'Nogales' sign near a no passing zone, on the south side of the road up on a hill. Grazed.

3-2 1 mile from 3-1, on the south side of the road up on a hill. Grazed.

3-3 1 mile from 3-2, on the south side of the road up on a hill. Grazed.
3-4 Mile post 21 on #82 near Patagonia City Limits (heading toward Nogales), on the north side of road over the fence on grazed area.

3-5 Heading to Nogales, 0.2 of a mile before mile post 17 on the south side of the road up on the hillside. Grazed area.

4 Cochise Co. Heading to Huachuca City/ Sierra Vista, AZ.

4-1 Exit #300 off of I-10 E. Up on the hill on the south side of the highway. Very deep clay soil. Many plants possess good clinging ability.

4-2 On State Highway #90, 0.4 miles south of I-10, on the west side of the road at the pull off area. Scattered patches in front of and over the fence. Over the fence is grazed.

4-3A 5 miles south of I-10 on #90, on the west side of the road.

4-3B Same location only on the east side of the road.

4-4 Mile post 298, 8.3 miles south of I-10 on #90. On the east side of the road up on a hill. A cobbly clay soil. These plants maintained good color on the range in December.

4-5 Mile post 308, 18.4 miles south of I-10 on #90 on the west side of the road near Whetstone, AZ. Growing through a patch of bermuda. This area was scraped for construction some time after the first collection visit.

4-6 Travelling west on #82 toward Sonoita, AZ. 3.7 miles west of #90 on #82. North side of the road, over in a heavily grazed area.

4-7 Mile post 46 on #82, 5.5 miles west of the junction of #90 & #82, On both sides of the road.
4-8 Mile post 44, 7.5 miles west of #90 on #82
4-9 11.5 miles west of #90 on #82, near the Elgin turnoff.

5 Cochise Co. On the way to Bisbee, AZ on US Highway #80. On the hill at the north east corner of the junction of US Highway #80 and State Highway #90.

5-1A South face of the hill at the bottom of the hill, a mixed batch of plant materials.

5-1B South face of the hill only higher up on the hill than 5-1A.

5-1 C, D, E
North face of the hill, all small patches, each accession is probably a separate clone.

6 Cochise Co. On US Highway #666 south, heading towards Douglas, AZ.

6-1 Mile post 45 on #666 (sort of near Pearce, AZ). On the east side of the road.

7 Santa Cruz Co. Heading toward Nogales, AZ. on State Highway #82, after the Patagonia collections.

7-1 19.6 miles west of #83 on #82 going to Nogales, AZ on the north side of the road.

7-2 0.9 miles after mile post 15 on #82 on the south side of the road over the fence in a grazed area.

7-3 0.1 of a mile before the 'Patagonia Lake State Park' sign. A large grazed area on the north side of the road in sandy clay soil.

7-4 0.1 to 0.2 of a mile before the 'North River Rd' sign, at the 'No Passing Zone' sign. A heavily grazed area on the north side of the road.

7-5 0.2 of a mile before 'Nogales City Limits' sign, on the north side of the road.
Pima Co. Gardener Canyon, AZ. (I-10 to State Highway #83 south). My thanks to Mr. Terry McGriff for this collection.

8-1 4.4 miles from the entrance of GC at #83. A vast area on the hillside on the north side of the road.

8-2 4.8 miles from the entrance of GC at #83. A vast area on the north side of the road.

8-3 5.4 miles from the entrance of GC at #83. A vast area on the north side of the road.

8-4 5.9 miles from the entrance of GC at #83. An area on the north side of the road.

9 Pima Co. Basically along the dirt road (Greaterville Road) that runs through the Coronado National Forest in the Santa Rita Mtns. from State Highway #83 west through Greaterville/ Helvetia and on to Continental, AZ.

9-1 Collected at the junction of I-10 and Highway #83, coming up the ramp onto #83. There is a small pull out area on the west that has a cement pillar. Grazed area over the fence, on a cobbly sandy clay.

9-2A Mile post 54 (100 yards after the milepost marker). One tuft of plant material on the west side of the highway. Very erectophile, found growing in sand. Not a grazed area. More than likely a clone.

9-2B Found 20 ft. west of 9-2A, a super-high density plant (maybe Hbe var longifolia), probably a clone but not from a grazed area.

9-3 0.5 miles west of #83 on Greaterville Rd., just as you are going around the first bend in the road. There is a hill on the north side of the road with a vast area of Hbe. The plant material from the hill is a good soil stabilizer, on the other side of the fence is heavily grazed.
9-4 4.5 miles west of #83. When travelling Greaterville Rd., bear left to 'Melendrez Pass', at the top of the hill, there is an incredibly large area of Hbe (acres of a very low growing phenotype) that forms a nice sward with low stature, short internodes and fine leaf texture. An excellent sod former.

9-5 Keep on going south on the road, and when you come to a gate that appears to be private property, go left up a moderately steep hill. At the top of the hill is a graveyard. Plant materials were collected outside of the graveyard where it was obvious that they had been run over by automobile tires (traffic tolerance). Short plants with short internodes, and an excellent sod former.

9-5B The Graveyard Accession. Collected inside the fencing of the graveyard at the top of the hill at the end of the road.

9-6 Now we are back on the Greaterville Rd. going west to Continental, AZ, approx. 0.5 miles after the 'Cattleman Co.' sign, after the second one lane bridge at the bottom of the canyon road.

10 Pima Co. Tucson Mountains/ Gates Pass, Tucson, AZ.

10-1 On Gates Pass Road approx. 1.5 miles past Scordatos Restaurant. On the east side of the road at the parking area before the parking area at Gates Pass. Growing in an incredibly hot cobbly volcanic soil way up on a hill facing south.

10-2 On the west side of Gates Pass, park in the parking area at the bottom of the hill. South-southwest up the hill from the parking area is a rather extensive patch that is quite visible from the parking area.

10-3 Collected at the upper most part of the big 10-2 patch.
10-4 Head up the trail that is east of the parking area at the bottom of the hill on the west side of Gates Pass. Approx. 0.25 of a mile up the trail there are scattered patches.

10-5 Continuing on the trail actually in the jeep trail and to the right, 100-200 ft. down the trail where the David Yetmen Trail starts.

11 Pima Co. Oro Valley, AZ on the north side of the Catalina Mtns.

11-1 Oracle Rd. north to Oro Valley, AZ. Before you get to the Canada del Oro pull off the road near a bunch of corals for horses. Look around, there is a trail to the east-southeast. Approx. 0.5 miles up the trail (south of Canada del Oro) there are scattered patches between the rocks on very steep rocky slopes.

11-2 0.5 of a mile further on this trail, again, very steep rocky habitat.

11-2B 50 ft. more down the trail, this plant material was growing in a very thick dense patch.

11-3 20 ft. further down the trail on the first switchback, a very dense patch in a very rocky area on very, very steep terrain.

12 Pima Co. Madera Canyon, Santa Rita Mtns.

12-1 Mile post 10 going into Madera Canyon, on the west side of the road, grazed.

12-2 Approx 0.8 miles past 12-2 on the west side of the road. Small very thick soddy patches growing in gravelly clay.
13 Pinal Co. Oracle Junction, AZ.

13-1 On State Highway #77 east of Oracle Junction, 0.5 miles before mile post 106, on the north side of the road. This is a relatively extensive patch scattered about the hill and is definitely grazed on the other side of the fence.

13-1B, C
Isolated patches with taller thicker clumps than other plants in the area.

13-1D A short growing patch on the other side of the fence on the hill.

13-1E An isolated patch.

13-1E HR (heavy roots)
Selected from 13-1E. These plants had a substantial number of roots initiated and the roots were in excess of 2 inches.

13-1F Patch on a steep eroding hill next to the roadside. Plants are short growing and have exceptional clinging ability.

14 Gila Co. On State Highway #77 past Winkelman, AZ. Turn left on Dripping Springs Rd. past mile post 152. Approx. 0.5 miles up the road on the left side of the road on top of an over-hang (just when you get to the top of the hill).

14-1, 14-2, 14-3
All of these accessions were collected in the same general area. These plants possess excellent early and late season color, display short leaves and low stature, and excellent stolon forming ability. Collected from a grazed area.

15 Gila Co. On State Highway #77 heading toward Globe, AZ. Near the sign 'Entering Tonto National Forest' and also 'Safety Pull Out 1/2 mile'.
15-1, 15-2
These accessions were collected at the site described above. Collected on the right side of #77. Plants were not really stoloniferous, but in fact were very dry and barely growing (dormant golden colored). Elevation is approx. 4980 ft.

15-3
Collected by Dr. Kneebone somewhere around San Carlos Lake. He claimed that it was the only green Hbe in the area while all other plants were dried.

16
Pima Co. Tucson Mtn. Foothills. Tucson, AZ. Camino de Suerte [CdS] (Grant Rd. west to Camino de Oeste, left on Camino de Oeste then look for Camino de Suerte on the east side of the road.

16-1
One hundred yards east on CdS on the north side of the road on the hill facing south. Rocky volcanic rock soil.

16-1A
An isolated patch on the south side of the road.

16-2
Collected further up the hill on the north side of the road under a big ocatillo.

16-3
A small patch on the south side of the road, at the lowest part of the road.

16-4
One hundred fifty yards (east) from the turn off onto CdS up the hill on the south side of the road. Spotty bunches with almost no other grasses in the area growing on rocky volcanic soil.

16-5
Further up the hill where the road begins to turn to the north. On the right side of the road, growing on deeper soil. Very thick growing plants with almost imperceptible stolons and long leaves.

17
17-1 Collected in what would be called the 'front yard', in the natural desert area south of the drive way.

17-2 Collected along the length of the south side of the drive way.

17-3 Collected along the length of the north side of the drive way.

17-4 Collected behind (west) of the house.

18 Cochise Co. Collected near the old Ghost town of Mescal, AZ. I-10 east to Mescal Rd., north on Mescal Rd.

18-1 Collected 2.7 miles north of I-10, from both sides of the road. The area is heavily grazed. You have to get out in to the range to find it. (Just south of a sign indicating a twisting turning road).

18-2 Collected 2.5 miles north of I-10, (0.2 miles south of #18-1) on the west side of the road.

19 Pima Co. Collected at #19000 south Sonoita Highway (State Highway #83), east off #83.

19-1 Collected just up the hill on the Rex Stump property on the north side of the road.

19-2 0.3 miles east of 19-1, on the north side of the road.

19-3 Take a left when the road goes left up to, but not on the 'Krash, Nevins and Whitney Ranch'. Collected just south of their property.

20 Origin of this plant material is unknown. It was obtained during Dr. Kneebone's collections. It existed for a long time known as Hbe 8.

20-1 Almost certainly a clone, has existed in the greenhouse for years known as Hbe 8. This material has a very dense growth habit.
21  Gila Co. Payson, AZ. Collected by Dr. Kneebone, exact origin of plant material is unknown.

21-1  Almost certainly a clone, has existed in the greenhouse for years known as Hbe 5.

22  Tucson, AZ. At the end of Sweetwater Rd. somewhere in the Tucson Mtns. An area only accessible by mountain bike.

22-1A, B; 22-1A, B
See above

22-3  An isolated patch growing in a wash (very sandy soil).

23  Origin of this plant material is unknown, it was collected by Dr. Kneebone.

23-1  Almost certainly a clone, has existed in the greenhouse for years known as A1.

23-2  Almost certainly a clone, has existed in the greenhouse for years known as A2.

24  Gila Co. Heading toward Showlow, AZ.

24-1  On State Highway #77 just past Globe, AZ. Elevation 5000 ft. Approx. 0.3 miles after mile post 264. On the right side of the road up on a hill.

24-1A  'Clinger' - Collected at the bottom of the hill clinging on to the soil.

24-2  Just as you are about to descend into the Salt River Canyon, on the right side of the road (sorry no mile post #). The area is grazed and the patch is large and dense. Clay soil with the plants growing between cobbly rocks. Elevation is approx. 5100 ft.

24-3  Just starting back up the Salt River Canyon after crossing the bridge. On the right side of the road at the 'Salt River Trading Post 500 ft' sign.
24-4 Just after the '7 Mile Wash' on the left side of the road. A grazed area up on top of the hill. Still growing and flowering on 13 Dec. Elevation is approx. 5200 ft. Near mile post 268.

24-5 Approx. 0.5 of a mile after mile post 306 on Highway #77 (just before you leave Gila County) on the left side of the road. An isolated patch on the top of the hill growing in Juniper litter. Elevation is approx. 5300 ft.

24-6 0.7 miles after mile post 278 on #70, on the right side of the road.

24-7 0.1 miles after mile post 288 on #77, on the left side of the road, just before descending into the Salt River Canyon, at a sign 'Seneca Lake Station now open 7 days'.

24-8 0.2 miles after mile post 284 on #77, at a sign 'Right Lane Ends 500 ft'. Approx. 5800 ft elevation. On the left side of the road, over the fence and under a large Juniper tree. Grazed at 0.5 inches, an excellent sod former.

25 Cochise Co. Heading toward Willcox, AZ on I-10 east.

25-1 Collected 0.5 miles after mile post 325 on I-10 east. On the right (south) side of the highway, over the fence approx. 200 yards. (You have to look for the red clay soil and then you will find the Hbe). Cobbly heavy clay soil. Grazed.

26 Cochise Co. Traveling north on US Highway #666 to Safford, AZ.

26-1 Collected at mile post 94 on #666, on the right side of the road over the fence in a grazed area with red clay soil.

26-1A Collected a small patch, this might be clonal.
26-1B Almost certainly a clone. These plant have a course texture with very strong stolons.

27 Graham Co. On State Highway #266 heading toward Bonita and Ft. Grant, AZ.

27-1 Collected at mile post 110 on #266, on the north side of the road. A massive patch on clay soil.

27-2 Collected approx. 100 yards before mile post 112 on #266. Another massive patch over the fence on the north side of the road that is heavily grazed.

28 Santa Cruz Co. Collected at the turnoff of Bull Spring Rd/Cottonwood Canyon and the road that goes up to the Whipple Observatory on Mt. Hopkins, in the Santa Rita Mtns. I-19 south to Amado, take Arivaca Rd east under I-19, south on the Frontage Rd, then on the dirt road for 4 miles.

28-1 Thin sparse plants with wiry, tough stolons on heavy red clay soil. Approx. 3000 ft elevation.

29 Graham Co. Collected in the Pinaleno Mtns., southwest of Safford, AZ. Take US Highway #666 north to State Highway #266 (to Ft. Grant-Bonita). Park at the US Game and Fish Reserve #665.

29-1 Collected at the 'Bar X Trick Tank, 3 miles from the entrance of USGF Reserve #665. Growing on a rocky hill side, many plant possess deep red stolons.

29-2 Collected 0.5 miles after 29-1, on the same dirt road, (actually in the Willcox Valley).

30 Pinal Co. Collected along the "Old Mt. Lemmon Highway' going to Pepper Sauce Cave.

30-1 One mile before the entrance to Pepper Sauce Cave.
31 Navajo Co. Heading toward Showlow, AZ on State Highway #77. Collected in Carizo Junction, AZ.

31-1 Collected along the left side of #77, 0.6 miles after mile post 317, and 0.5 miles before State Highway #73. Approx. 5500 ft elevation. Nice spreading patches with short internodes, growing on heavy red clay soil.
APPENDIX C

SELECTED REFERENCES PERTAINING TO STATISTICAL THEORY, BIOMETRICAL GENETICS, AND POPULATION IMPROVEMENT


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