IT'S NOT ALL YOUR FAULT

Jim **Thompson**

It's True What They Say, Not All Equipment Matches All Equipment.

Beekeeping operations come in all sizes: from one hive to thousands of hives. Beekeepers can get their hives new from a beekeeping supply manufacturer, or second hand from a yard sale, auction or a retiring beekeeper. Thus it is likely that a beekeeper will somewhere along the line end up with equipment made by different manufacturers, and much of this equipment appears interchangeable. However, this is not exactly true because different manufacturers build their hives slightly differently, and a few fractions of an inch difference can cause enormous problems when it comes time to work with the hive. This is because the bees will wall off gaps that are too small for the bee with propolis, and will build comb to span spaces larger than a bee. Either event results in more work for the beekeeper. An article by Heilman and Thompson in 2001 examined the fit between shallow, medium and large supers for a few manufacturers. However, equipment and manufacturers change. So I decided to revisit this issue to help beekeepers decide if it is worth their time and money to use equipment from multiple manufacturers. While I cannot test every product on the market, I tested large supers and frames from 10 manufacturers in all possible combinations. In addition to showing the compatibility amongst these manufacturers, I hope that this article provides guidance on how to determine if equipment I did not measure will work under your beekeeping conditions.

In working on this project, it became apparent that several combinations would cause a beekeeper grief due to: 1) A space smaller than a bee between frames of one super and the frames of the adjacent super which encourages bees to use propolis to join the frames together. 2) A space larger than a bee between adjacent supers thereby allowing the bees the opportunity to build brace comb. The difference, not too small and not too large, is known as the bee space. It was discovered sometime in the late 19th century, and the idea of a bee space was formally entered into the scientific literature by the efforts of two individuals: H.C.J. Dzierzon (1811-1906), and L.L. Langstroth (1810-1895). The earliest published record I could find for the use of bee space by Langstroth was his 1879 book. Charles Dadant and Son revised Langstroth's "Langstroth on the Hive and the Honey-Bee", and "bee space" is mentioned as such on paragraph 286 in the 1896 (3rd) edition.

The correct "bee space" has been determined to be a space between 1/4" (0.250") and 3/8" (0.375") with 5/16" (0.3125") being the optimum. However, bee space can vary with other factors, such as foundation type, comb age in the brood area, race of honey bee, climate, geography and hive composition. Furthermore, smaller cell foundation may cause emerging bees to develop sooner, be smaller, and thus have a smaller bee space. Comb that has been used for many years may have a smaller cell size due to the propolis and cocoon coatings inside the cell that were made by the bees sanitizing the cell for the next generation of brood. The materials used in hive construction can pose a problem because wood expands and contracts with weather conditions. This expansion and contraction could result in improper bee space in an otherwise well made hive. The solution is to select woods that have a lower expansion coefficient or use

only quarter sawn lumber which may be more expensive or wasteful, if sawing your own lumber (Doyle 1995).

The equipment used in this article was purchased from: Beeline Apiaries (Jonathan Showalter, 5765 Main Rd. Bedford, PA 15522), Brushy Mountain Bee Supply (610 Bethany Church Rd, Moravian Falls, NC 28654), Dadant & Sons (51 South 2nd, Hamilton, IL 62341), Humble Abodes (636 Coopers Mills Rd. Windsor, ME 04363), Walter T. Kelley Company (PO Box 240 807 W. Main Street Clarkson, KY 42726), Mann Lake Bee Supply (501 S. 1st St. Hackensack, MN 56452-2001), Rossman Apiaries (Rossman Apiaries Inc. P. O. Box 909, Moultrie, GA 31776-0909), Bee's Forever Plastics (16730 County Road 96, Woodland, CA 95695), Mother Lode Products (**www.motherlodeproducts.com**: accessed 20 June 2010), and Pierco Frames (**www.pierco.net/index.htm**: accessed 20 June 2010). The equipment was purchased in a manner as to get a representative example of the equipment without getting specially selected items. Some bee supply companies order their equipment from these manufacturers, and I tried to avoid duplication. However some of the equipment appeared to be similar to others that were obtained. In this article I compared only deep supers and frames.

All pieces were measured within one week of receipt to minimize distortion due to the expansion/contraction of wood adjusting to our Ohio climate. Measurements were taken using depth micrometers, outside micrometers and digital calipers were used along with a bar and jig. The larger dimensions were measured using a combination square. To measure ear thicknesses I made a mark ¼" in from the end of the frame where the measurements were taken. On frames that have ears cut on an angle, this mark would assure that the measurements were at the point of contact with the frame rest. Another mark was made at the center of the top bar where the top gap measurements were taken. This was necessary to make up for ear thickness differences. All calculations for bee space were made using the frame with the smallest difference in ear thickness between the two sides. Furthermore, the supers were not cut uniformly. Some supers had different side heights relative to end heights and some side heights were tapered. When the equipment was ordered it was budget or commercial grade. All measurements were entered into an Excel 2007 spreadsheet (**www.Microsoft.com**), and all calculations were done using this software.

Over the years I have learned that assembly of the supers is not as simple as the directions that come with the kits (if indeed there were directions). Many times the wood has a slight warp or twist and if you start nailing at one corner and continue around, the joints seem to move and you get a super that will not sit flat. I like to dry fit the four sides to see if they actually will go together and to make sure that the hand holds are on the outside. Then I open up the joints, apply glue and put them back together. I used deck screws to assemble the supers because it seems to pull the wood together better than nails. If you start with the middle box joint on the long side then fasten the two fingers on the adjacent end and work your way to the top and bottom of the box and around the box by alternating fingers you can work out many of the warping problems. When assembling frames I recommend that glue be used and be sure to drive a

Super Depth

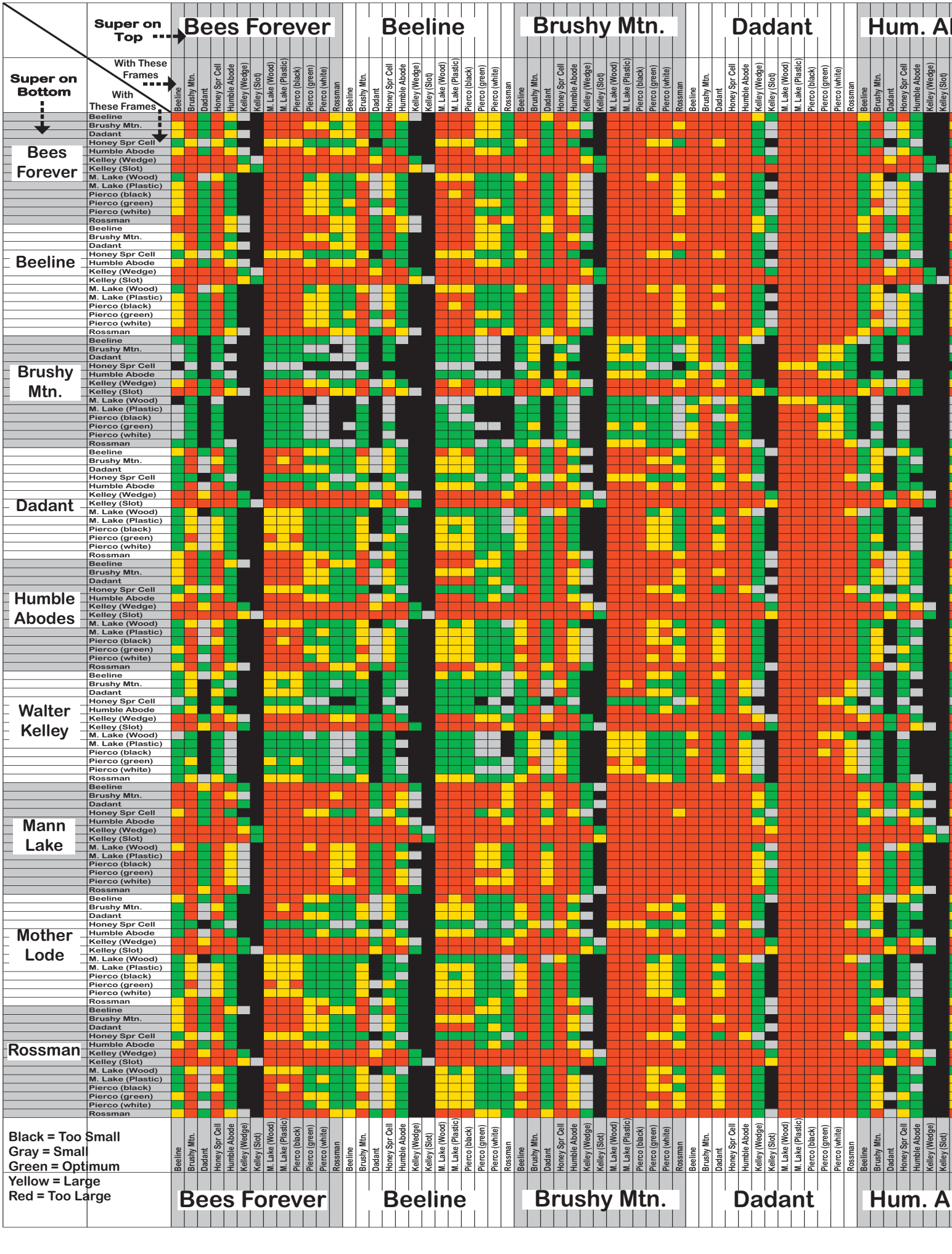
Frame Depth

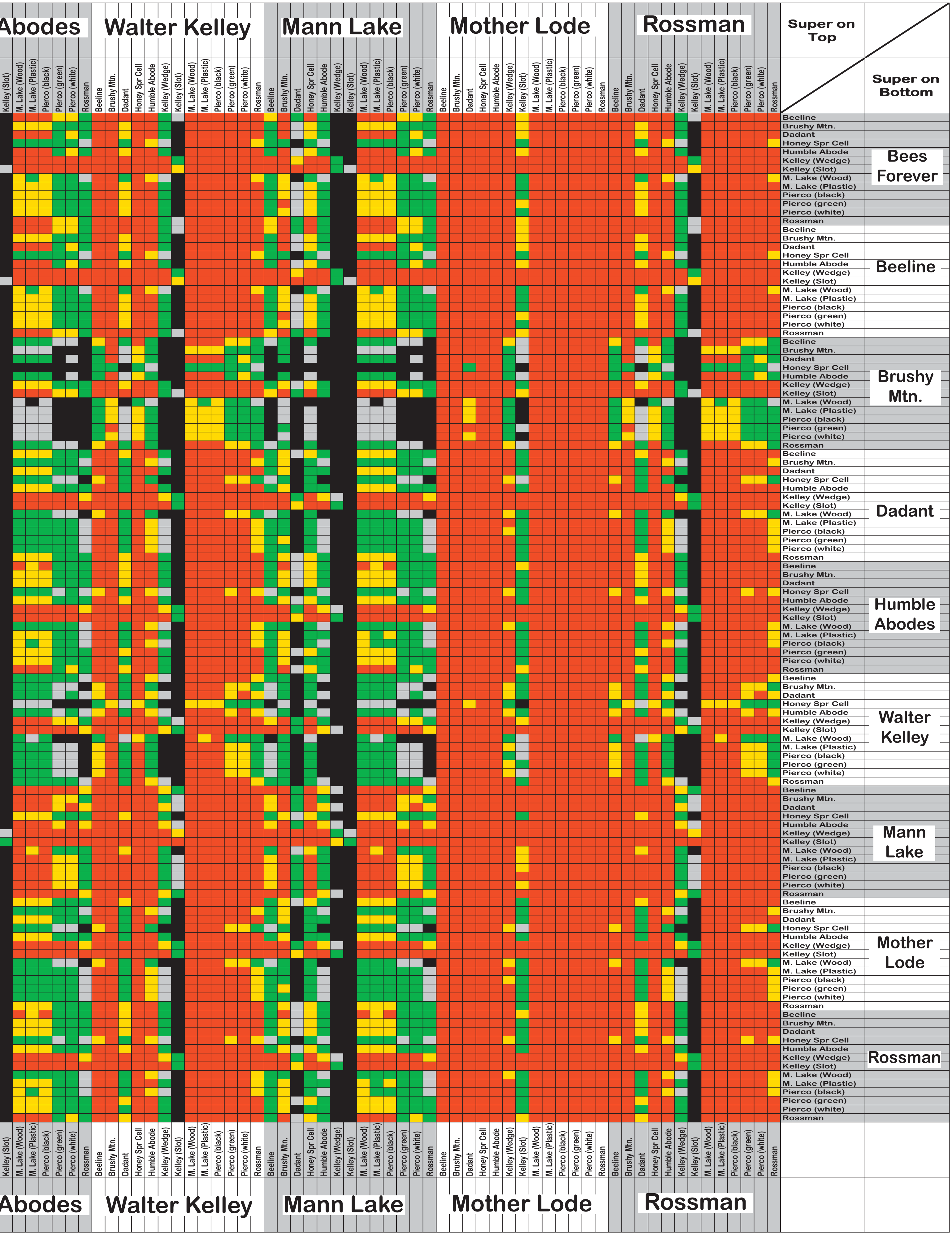
Calculating the difference.

Table 2: Top and bottom gaps for all combinations of frame and super from ten different manufacturers.

Deep Super	Frame	Rabbit	Ear Height	Top Gap	Super Height	Frame Height	Bottom Gap
Bees Forever	Beeline	0.6250	0.4078	0.2172	9.5195	9.1328	0.1695
Bees Forever	Brushy Mtn.	0.6250	0.4289	0.1961	9.5195	9.1086	0.2148
Bees Forever	Dadant	0.6250	0.4210	0.2040	9.5195	9.2070	0.1085
Bees Forever	Honey Super Cell	0.6250	0.4675	0.1575	9.5195	9.1578	0.2042
Bees Forever	Humble Abode	0.6250	0.4216	0.2034	9.5195	9.1688	0.1473
Bees Forever	Kelley (Wedge)	0.6250	0.3483	0.2767	9.5195	9.1899	0.0529
Bees Forever	Kelley (Slot)	0.6250	0.3145	0.3105	9.5195	9.2250	-0.0160
Bees Forever	M. Lake (Wood)	0.6250	0.4567	0.1684	9.5195	9.1375	0.2137
Bees Forever	M. Lake (Plastic)	0.6250	0.4383	0.1868	9.5195	9.1250	0.2078
Bees Forever	Pierco (black)	0.6250	0.4425	0.1825	9.5195	9.1250	0.2120
Bees Forever	Pierco (green)	0.6250	0.4290	0.1960	9.5195	9.1524	0.1711
Bees Forever	Pierco (white)	0.6250	0.4375	0.1875	9.5195	9.1563	0.1757
Bees Forever	Rossman	0.6250	0.4052	0.2198	9.5195	9.1547	0.1450
Beeline	Beeline	0.6250	0.4078	0.2172	9.5000	9.1328	0.1500
Beeline	Brushy Mtn.	0.6250	0.4289	0.1961	9.5000	9.1086	0.1953
Beeline	Dadant	0.6250	0.4210	0.2040	9.5000	9.2070	0.0890
Beeline	Honey Super Cell	0.6250	0.4675	0.1575	9.5000	9.1578	0.1847
Beeline	Humble Abode	0.6250	0.4216	0.2034	9.5000	9.1688	0.1278
Beeline	Kelley (Wedge)	0.6250	0.3483	0.2767	9.5000	9.1899	0.0334
Beeline	Kelley (Slot)	0.6250	0.3145	0.3105	9.5000	9.2250	-0.0355
Beeline	M. Lake (Wood)	0.6250	0.4567	0.1684	9.5000	9.1375	0.1942
Beeline	M. Lake (Plastic)	0.6250	0.4383	0.1868	9.5000	9.1250	0.1883
Beeline	Pierco (black)	0.6250	0.4425	0.1825	9.5000	9.1250	0.1925
Beeline	Pierco (green)	0.6250	0.4290	0.1960	9.5000	9.1524	0.1516
Beeline	Pierco (white)	0.6250	0.4375	0.1875	9.5000	9.1563	0.1562
Beeline	Rossman	0.6250	0.4052	0.2198	9.5000	9.1547	0.1255
Brushy Mtn.	Beeline	0.5313	0.4078	0.1235	9.4570	9.1328	0.2007
Brushy Mtn.	Brushy Mtn.	0.5313	0.4289	0.1024	9.4570	9.1086	0.2460
Brushy Mtn.	Dadant	0.5313	0.4210	0.1103	9.4570	9.2070	0.1397
Brushy Mtn.	Honey Super Cell	0.5313	0.4675	0.0638	9.4570	9.1578	0.2354
Brushy Mtn.	Humble Abode	0.5313	0.4216	0.1097	9.4570	9.1688	0.1786
Brushy Mtn.	Kelley (Wedge)	0.5313	0.3483	0.1830	9.4570	9.1899	0.0841
Brushy Mtn.	Kelley (Slot)	0.5313	0.3145	0.2168	9.4570	9.2250	0.0152
Brushy Mtn.	M. Lake (Wood)	0.5313	0.4567	0.0746	9.4570	9.1375	0.2449
Brushy Mtn.	M. Lake (Plastic)	0.5313	0.4383	0.0930	9.4570	9.1250	0.2390
Brushy Mtn.	Pierco (black)	0.5313	0.4425	0.0888	9.4570	9.1250	0.2433
Brushy Mtn.	Pierco (green)	0.5313	0.4290	0.1023	9.4570	9.1524	0.2024
Brushy Mtn.	Pierco (white)	0.5313	0.4375	0.0938	9.4570	9.1563	0.2070
Brushy Mtn.	Rossman	0.5313	0.4052	0.1261	9.4570	9.1547	0.1762
Dadant	Beeline	0.5938	0.4078	0.1860	9.5703	9.1328	0.2515
Dadant	Brushy Mtn.	0.5938	0.4289	0.1649	9.5703	9.1086	0.2968
Dadant	Dadant	0.5938	0.4210	0.1728	9.5703	9.2070	0.1905
Dadant	Honey Super Cell	0.5938	0.4675	0.1263	9.5703	9.1578	0.2862
Dadant	Humble Abode	0.5938	0.4216	0.1722	9.5703	9.1688	0.2294
Dadant	Kelley (Wedge)	0.5938	0.3483	0.2455	9.5703	9.1899	0.1349
Dadant	Kelley (Slot)	0.5938	0.3145	0.2793	9.5703	9.2250	0.0660
Dadant	M. Lake (Wood)	0.5938	0.4567	0.1371	9.5703	9.1375	0.2957
Dadant	M. Lake (Plastic)	0.5938	0.4383	0.1555	9.5703	9.1250	0.2898
Dadant	Pierco (black)	0.5938	0.4425	0.1513	9.5703	9.1250	0.2941
Dadant	Pierco (green)	0.5938	0.4290	0.1648	9.5703	9.1524	0.2532
Dadant	Pierco (white)	0.5938	0.4375	0.1563	9.5703	9.1563	0.2578
Dadant	Rossman	0.5938	0.4052	0.1886	9.5703	9.1547	0.2270
H. Abodes	Beeline	0.6094	0.4078	0.2016	9.4688	9.1328	0.1344
H. Abodes	Brushy Mtn.	0.6094	0.4289	0.1805	9.4688	9.1086	0.1797
H. Abodes	Dadant	0.6094	0.4210	0.1884	9.4688	9.2070	0.0734
H. Abodes	Honey Super Cell	0.6094	0.4675	0.1419	9.4688	9.1578	0.1691
H. Abodes	Humble Abode	0.6094	0.4216	0.1878	9.4688	9.1688	0.1123
H. Abodes	Kelley (Wedge)	0.6094	0.3483	0.2611	9.4688	9.1899	0.0178
H. Abodes	Kelley (Slot)	0.6094	0.3145	0.2949	9.4688	9.2250	-0.0511
H. Abodes	M. Lake (Wood)	0.6094	0.4567	0.1527	9.4688	9.1375	0.1786
H. Abodes	M. Lake (Plastic)	0.6094	0.4383	0.1711	9.4688	9.1250	0.1727
H. Abodes	Pierco (black)	0.6094	0.4425	0.1669	9.4688	9.1250	0.1769
H. Abodes	Pierco (green)	0.6094	0.4290	0.1804	9.4688	9.1524	0.1361
H. Abodes	Pierco (white)	0.6094	0.4375	0.1719	9.4688	9.1563	0.1406
H. Abodes	Rossman	0.6094	0.4052	0.2042	9.4688	9.1547	0.1099

Kelley	Beeline	0.5625	0.4078	0.1547	9.5157	9.1328	0.2282
Kelley	Brushy Mtn.	0.5625	0.4289	0.1336	9.5157	9.1086	0.2735
Kelley	Dadant	0.5625	0.4210	0.1415	9.5157	9.2070	0.1672
Kelley	Honey Super Cell	0.5625	0.4675	0.0950	9.5157	9.1578	0.2629
Kelley	Humble Abode	0.5625	0.4216	0.1409	9.5157	9.1688	0.2060
Kelley	Kelley (Wedge)	0.5625	0.3483	0.2142	9.5157	9.1899	0.1116
Kelley	Kelley (Slot)	0.5625	0.3145	0.2480	9.5157	9.2250	0.0427
Kelley	M. Lake (Wood)	0.5625	0.4567	0.1059	9.5157	9.1375	0.2724
Kelley	M. Lake (Plastic)	0.5625	0.4383	0.1243	9.5157	9.1250	0.2665
Kelley	Pierco (black)	0.5625	0.4425	0.1200	9.5157	9.1250	0.2707
Kelley	Pierco (green)	0.5625	0.4290	0.1335	9.5157	9.1524	0.2298
Kelley	Pierco (white)	0.5625	0.4375	0.1250	9.5157	9.1563	0.2344
Kelley	Rossman	0.5625	0.4052	0.1573	9.5157	9.1547	0.2037
Mann Lake	Beeline	0.6563	0.4078	0.2485	9.5156	9.1328	0.1343
Mann Lake	Brushy Mtn.	0.6563	0.4289	0.2274	9.5156	9.1086	0.1796
Mann Lake	Dadant	0.6563	0.4210	0.2353	9.5156	9.2070	0.0733
Mann Lake	Honey Super Cell	0.6563	0.4675	0.1888	9.5156	9.1578	0.1690
Mann Lake	Humble Abode	0.6563	0.4216	0.2347	9.5156	9.1688	0.1122
Mann Lake	Kelley (Wedge)	0.6563	0.3483	0.3080	9.5156	9.1899	0.0177
Mann Lake	Kelley (Slot)	0.6563	0.3145	0.3418	9.5156	9.2250	-0.0512
Mann Lake	M. Lake (Wood)	0.6563	0.4567	0.1996	9.5156	9.1375	0.1785
Mann Lake	M. Lake (Plastic)	0.6563	0.4383	0.2180	9.5156	9.1250	0.1726
Mann Lake	Pierco (black)	0.6563	0.4425	0.2138	9.5156	9.1250	0.1768
Mann Lake	Pierco (green)	0.6563	0.4290	0.2273	9.5156	9.1524	0.1360
Mann Lake	Pierco (white)	0.6563	0.4375	0.2188	9.5156	9.1563	0.1405
Mann Lake	Rossman	0.6563	0.4052	0.2511	9.5156	9.1547	0.1098
Mother Lode	Beeline	0.5938	0.4078	0.1860	9.6563	9.1328	0.3375
Mother Lode	Brushy Mtn.	0.5938	0.4289	0.1649	9.6563	9.1086	0.3828
Mother Lode	Dadant	0.5938	0.4210	0.1728	9.6563	9.2070	0.2765
Mother Lode	Honey Super Cell	0.5938	0.4675	0.1263	9.6563	9.1578	0.3722
Mother Lode	Humble Abode	0.5938	0.4216	0.1722	9.6563	9.1688	0.3154
Mother Lode	Kelley (Wedge)	0.5938	0.3483	0.2455	9.6563	9.1899	0.2209
Mother Lode	Kelley (Slot)	0.5938	0.3145	0.2793	9.6563	9.2250	0.1520
Mother Lode	M. Lake (Wood)	0.5938	0.4567	0.1371	9.6563	9.1375	0.3817
Mother Lode	M. Lake (Plastic)	0.5938	0.4383	0.1555	9.6563	9.1250	0.3758
Mother Lode	Pierco (black)	0.5938	0.4425	0.1513	9.6563	9.1250	0.3801
Mother Lode	Pierco (green)	0.5938	0.4290	0.1648	9.6563	9.1524	0.3392
Mother Lode	Pierco (white)	0.5938	0.4375	0.1563	9.6563	9.1563	0.3438
Mother Lode	Rossman	0.5938	0.4052	0.1886	9.6563	9.1547	0.3130
Rossman	Beeline	0.6094	0.4078	0.2016	9.5625	9.1328	0.2281
Rossman	Brushy Mtn.	0.6094	0.4289	0.1805	9.5625	9.1086	0.2734
Rossman	Dadant	0.6094	0.4210	0.1884	9.5625	9.2070	0.1671
Rossman	Honey Super Cell	0.6094	0.4675	0.1419	9.5625	9.1578	0.2628
Rossman	Humble Abode	0.6094	0.4216	0.1878	9.5625	9.1688	0.2060
Rossman	Kelley (Wedge)	0.6094	0.3483	0.2611	9.5625	9.1899	0.1115
Rossman	Kelley (Slot)	0.6094	0.3145	0.2949	9.5625	9.2250	0.0426
Rossman	M. Lake (Wood)	0.6094	0.4567	0.1527	9.5625	9.1375	0.2723
Rossman	M. Lake (Plastic)	0.6094	0.4383	0.1711	9.5625	9.1250	0.2664
Rossman	Pierco (black)	0.6094	0.4425	0.1669	9.5625	9.1250	0.2706
Rossman	Pierco (green)	0.6094	0.4290	0.1804	9.5625	9.1524	0.2298
Rossman	Pierco (white)	0.6094	0.4375	0.1719	9.5625	9.1563	0.2343
Rossman	Rossman	0.6094	0.4052	0.2042	9.5625	9.1547	0.2036


Super on Top
Bees Forever
Beeline
Brushy Mtn.
Dadant
Hum. A
With These Frames
Super on Bottom
With These Frames
Beeline
Brushy Mtn.
Dadant
Honey Spr Cell
Humble Abode
Kelley (Wedge)
Kelley (Slot)
M. Lake (Wood)
M. Lake (Plastic)
Pierco (black)
Pierco (green)
Pierco (white)
Rossman
Bees Forever
Beeline
Brushy Mtn.
Dadant
Humble Abodes
Walter Kelley
Mann Lake
Mother Lode
Rossman
Black = Too Small
Gray = Small
Green = Optimum
Yellow = Large
Red = Too Large



Abodes
Walter Kelley
Mann Lake
Mother Lode
Rossman
Super on Top
Super on Bottom
Kelley (Slot)
M. Lake (Wood)
M. Lake (Plastic)
Pierco (black)
Pierco (green)
Pierco (white)
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Kelley (Slot)
M. Lake (Wood)
M. Lake (Plastic)
Pierco (black)
Pierco (green)
Pierco (white)
Rossman

Table 1: Measurements for frames and supers from different manufacturers. Measurements are in inches. Measurements are the average ± one standard deviation (sample size). Blanks occur when manufacturers don't make all pieces of equipment.

	Deep Supers				Frames		
Manufacturer	**Super Height**	**Rabbit Depth**	**Outside Length**	**Outside Width**	**Frame Depth**	**Ear Height**	**Top Bar Length**
Bee Forever	9.5195[1]	0.6250	19.7813	16.1250			
Beeline	9.5000[2]	0.6250	19.8750	16.2500	9.1328±0.0095 (20)[3]	0.4078±0.0074 (20)	19.0000
Brushy Mtn.	9.4570[4]	0.5313	19.8750	16.1875	9.1086±0.0113 (10)[5]	0.4289±0.0078 (19)	18.9375
Dadant	9.5703[6]	0.5938	19.8750	16.2500	9.2070±0.0951 (10)[7]	0.4210±0.0087 (20)	18.9375
Honey Super Cell					9.1578±0.0110 (2)[8]	0.4675±0.0319 (4)	18.9375
Humble Abode	9.4688[9]	0.6094	19.8750	16.2500	9.1688±0.0200 (20)[10]	0.4216±0.0226 (20)	18.9375
Kelley (wedge)	9.5157[11]	0.5625	19.8750	16.2500	9.1899±0.0075 (10)[12]	0.3483±0.0090 (20)	18.9375
Kelley (slot)					9.2250±0.0109 (20)[13]	0.3145±0.0036 (20)	18.9375
M. Lake (wood)	9.5156[14]	0.6563	19.8750	16.3125	9.1375±0.0109 (20)[15]	0.4567±0.0036 (20)	18.9688
M. Lake (plastic)					9.1250±0.0000 (2)[16]	0.4383±0.0109 (4)	18.9688
Mother Lode	9.6563[17]	0.5938	19.9375	16.2500			
Pierco (black)					9.1250±0.0000 (2)[18]	0.4425±0.0087 (4)	18.9375
Pierco (green)					9.1524±0.0000 (2)[19]	0.4290±0.0027 (4)	18.9063
Pierco (white)					9.1563±0.0000 (2)	0.4375±0.0084 (4)	19.0000
Rossman	9.5625[20]	0.6094	19.8750	16.2500	9.1547±0.0137 (10)[21]	0.4052±0.0133 (20)	18.9375

1) One piece plastic super, round corners inside and out. Has roughened edges to prevent slippage and two holes on each side for placement of pins. Will take a 19" long frame with very little extra room.
2) Some drilling and filing required on super, possibly due to purchasing budget grade. Will take a frame up to 19.125" long.
3) Top Bar on frame has angular frame rest seats and square ends. The dadoes have joints flush at the top and bottom. There was some variation between ear thicknesses on the same top bar.
4) Shallow cut for the frame rest and incorporated with the first box joint makes a stronger area, needed when beekeepers pry on the frame. Will take a frame up to 19.25" long.
5) Top Bar has angular frame rest seats, round (clipped) ends and is 1.125" wide. The dadoes are set so the joints at the top and bottom are flush.
6) Included "L" metal frame rest and enough nails to assemble. Will take a frame up to 19.125" long. Measured with metal in place.
7) The wood frame had rounded (clipped) ends and an angular frame rest seat for better centering. The bottom bar was 0.5313" thick, making a sturdy frame. Their EZ plastic frame was made by Pierco.
8) Plastic, fully drawn cells, with straight sided end bars. Ears have angular portion for centering and flat area for the frame rest. Top of frame has a center rib which is not the same height as the edges. Top rib was not trimmed evenly. Measurements were taken off of edges which were the highest points.
9) Will take frame up to 19.1563".
10) Top Bar has angular frame rest seat for better centering and squared off ends. End bars are cut to 9.125" but the rabbits are not cut deep enough for the bottom bar or top bar to be flush.
11) Sent with raised metal frame rest and an abundance of nails. Will take a frame up to 19.0625" long. Measured over metal
12) Flat portion above frame rest. Rounded end bars for frame spacing. Frames were fairly consistent with each other, most were within 0.012"
13) New, slot in top bar for insertion of foundation. Extra wide (0.5+") slotted end bars would help keep foundation straight. Dadoes in end bars are not deep enough to make flush joints on top and bottom.
14) Will take a frame up to 19.125" long.
15) Top Bar has a slight angle to the frame rest seat and the ends are rounded (clipped). The bottom bar is slightly over 0.5" thick which gives the frame strength. The dado joints provide flush fits. End bars were clipped to aid in assembly but leave dimples on the top of the frame. Most of the ears of a frame were cut within a tolerance of 0.002" of each other.
16) Appearance similar to Pierco with thinner walls.
17) Plastic Super that snaps together made to close tolerances so a lubricant is suggested and assembly when plastic is warm. The 0.5" wide frame rest overhangs on the inside of the super 0.131". Super is light in weight and has tabs that will help it from sliding on the bottom board or the super below. Has room for a 19.125" frame
18) Plastic foundation frame made with food grade materials, ear tapered near end bar then flat over frame rest.
19) These frames were part of a prototype batch, and therefore might not be typical of mass production frames.
20) Rabbit Jointed Super and enough nails to assemble equipment. Made of Cypress so super is heavier than the pine supers and more weather resistant. Will hold a frame up to 19.125" long.
21) Tapered ear over frame rest to aid in centering.

horizontal nail through the end bar into the top bar. If you can use long staples on the frames, they hold better than nails.

To measure the bottom gap I made a device that would hold all the frames against the frame rest and I could measure across. After several measurements, I noticed that not all of the frames were making contact when all 10 frames were in the super. Thus I measured the frames, two at a time to assure they were fully seated against the frame rest. To double check the measurements, I added the smaller measurements to see if they were equal to the height of the super.

The frame measurements and hive measurements are listed in Table 1. From these measures I calculated top and bottom gaps, and produced a quick reference color chart (Figure 1) based on these values. Another chart is available on-line that shows the numeric values for the space between frames when used with various supers.

The super and frame combination reading across the top of the chart represent the super that was placed over the super and frame combinations listed on the left of the chart. In the color coded chart (Figure 1), green is used for the optimum bee space standards. Gray was used for a space between the optimum and ¼" (still within limits) Black was used when the space is below ¼", and that could cause bees to use propolis. Yellow was used to indicate a space greater than optimum up to 3/8" (but still within limits). Red was used to signal a space greater than 3/8", and that may cause the bees to add brace comb. One manufacturer made a comment that they knew they had exceeded the normal bee space. They thought that it was easier for the beekeeper scrape off the extra wax than to break apart propolis. I would have to agree, and evidently many others do also as there is an abundance of red on the chart.

There are several possible causes for this wide variation in bee space for a manufacturer. A manufacturer might use materials or might have parts manufactured outside the U.S. In some cases different countries could have different sizes for lumber, and even within the U.S. lumber standards have not always been the same. The first national standard in the U.S. started in 1924, but these changed considerably in the early part of the 20th century (Smith 1964). Parts manufactured internationally will often be made in countries that have adopted the metric system. Pieces imported from these countries will be sold as their nearest English equivalent in the U.S. This introduces a round-off error that will affect how the hives fit together and their compatibility with other equipment.

At some point in history, the frame for a deep super was determined to be 9-1/8" tall and with the maximum bee space of 3/8" a super should be 9½" tall. The 3/8" bee space could be on top of the frames making the bottom bar flush with the bottom of the super. You could have the 3/8" under the frames, causing the top bars to be flush with the top of the super. The third option is to split the bee space on top and bottom of the frames and is the method used by most manufacturers. Consistency is what is important with spacing and is usually determined by the depth of the frame rest, depth of the frame and the height of the super. Langstroth suggested using a ¼" top gap and a ⅛" bottom gap. With this spacing one may put a piece of equipment that is flat on the bottom

Carefully measuring frame consistancy.

on top of the super and have the minimum bee space. If a super is stacked on top of another, you approach the upper limit of bee space.

It is not possible to rank the equipment as to which is best and which is worst. The specific ranking would depend on the specific conditions under which the equipment was to be used and how the beekeeper maintains his equipment. For the most part the manufacturer does not matter if purchasing his first super and frame and he sets up only one hive. If the beekeeper is buying several hundred, cost is probably the biggest concern, though care should be exercised that bee space is maintained as the new hives are integrated into the existing operation. Most of the equipment had some problems. One company had nine frames that were very close in tolerance and one frame with an ear that was ½ the size of the others. Another company had good joints on the frames but shallow cuts on the box joints. Still another company had shallow dado cuts on their frames causing the frames to hang below the bottom of some supers. One company sent a super with one side 1/8" shallower than the end boards, causing me to file and adjust the box joints. All of the companies produced equipment with tight joints.

With the exception of Mann Lake and Rossman, all the equipment by each manufacturer was within the limits of bee space as it has been defined. To show how close they are from being within tolerances: If Mann Lake took 0.0031" off the height of their super the wood

Top bar thickness.

frame would be within the upper limits of bee space. If they took 0.0156" (1/64") off the height of their super, the plastic frame would be within the upper limits of bee space. If the Rossman frame was reduced 0.0297" (less than 1/32") in height, it would be within the upper limits of bee space.

An item that is more serious is the fit of equipment where bee space is too small. This is indicated by the black color. The majority of the black color is noticed when Kelley frames were used in other manufacturers' supers. The end bars measure 9-1/8" but the top and bottom bars could be recessed deeper to make sure the frame is actually 9-1/8" deep. It is interesting to notice that while the Kelley frames do not fit well with the other supers, they do fit in Mother Lode's super. The Mother Lode's super is over 9-5/8" deep which is about 1/8" deeper than most of the others. This accounts for the solid red color in the Mother Lode area of the chart.

If you have equipment that doesn't provide you with the proper bee space there are three things that you can do. 1) Raise or lower the frame rest. This may be accomplished by adding a shim on the frame rest or fastening a piece of metal across the end of the super so the frame is held at the proper level. If the frame rest is too high, you might use a router and cut it down to the proper level. 2) Increase or reduce the height of the super. This is done by adding a sliver of wood to the bottom of the super or cutting the super down to the desired height. Before you start cutting do some measuring, the super should be equal to the height of the frame plus 3/8". 3) You could do nothing and carry a container to put the extra wax in or use two hive tools, one tool to hold the super up while you pry the frames loose with the other.

It is not all your fault that the equipment you buy doesn't have the correct bee space. BC

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Measuring space between bottom bar.

Tools and forms used to set up and measure the equipment.