

Supplementary material

A high-resolution linkage map for the Z chromosome in chicken reveals hot spots for recombination

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Supplementary Table 1. Primer sequences and corresponding sequence contigs (February 2004 assembly) assigned to chicken chromosome W in this study.

Primer	Contig	Sequence 5'-3'
rs14691881_F	1029.4	ACAGTCATCATCCAATCGCAGTG
rs14691881_R		GTGGGGATGGGAGAATGTGAGTA
rs13804259_F	1464.1	TGTCTCATTTCAGTCAAACCTACG
rs13804259_R		AACAAATGAAAATCCAGAAAACA
rs14703291_F	1769.2	TCATTTACACCAAGACAGACAC
rs14703291_R		TGCAAAGAATTCAAACACAAATG
rs14704770_F	1904.1	TTCCAGTTCACCCATTTCAAGC
rs14704770_R		TACATTATTCCATCCGTTACAC
rs14739111_F	638.2	AGAAAACAGAGAAAACAGAAAAC
rs14739111_R		CAATACTAAAAGAAGGATACAGGA
rs14739961_F	658.8	CAATCAGGACAGGGTTTTAAGC
rs14739961_R		CCTCCAAAAGTGAGGAAACATC
rs13816857_F	954.7	AGGCAAAGATGAAAAGTACACCA
rs13816857_R		GGCATTGGAATACATTTGAGA
rs14748167_F	986.3	GAACATTTGCAGTGAAATCAACA
rs14748167_R		CACTTTAAATTGGAGCATTTTGC
rs16708822_F	2157.3	ATGGGAGAAAGTCTGGAGAAATC
rs16708822_R		AGGCTTTTCTCCCTCTTAATTT

Supplementary Table 2. Markers included in the chicken chromosome Z linkage map. The map position in Kosambi centiMorgans (cM) and the positions on both the 2004 and 2006 assemblies are given. Markers within bins are sorted on the basis of the position in the 2006 assembly.

Linkage map	cM	Genome assembly position		Marker	cM	Z:position(bp)	Z:position(bp)
		February 2004	May 2006				
rs14735985	0.0	UN:136,383,361	UN:33,014,441	rs14757505 ¹	51.7	Z:7,789,062	Z:14,225,605
rs15993913	8.8	UN:4,744,378	Z:711,341	rs16103666	51.7	Z:7,843,713	Z:14,281,917
rs15993489	13.1	UN:4,385,106	Z:1,097,548	rs14757661	51.7	Z:8,035,916	Z:14,483,557
rs16098196	17.5	Z:5,211	UN:41,283,873	rs16104056	51.7	Z:8,985,450	Z:15,449,751
rs16077650	19.6	UN:140,458,402	Z:1,155,544	rs16104210	51.7	Z:9,294,940	Z:15,777,843
rs16077650	19.6	UN:132,416,459	Z:1,388,262	rs16098534	55.9	Z:510,431	Z:16,386,097
rs15002180	19.6	14:1,405,031	Z:1,596,721	rs14752429	58.1	Z:990,516	Z:16,883,737
rs15002117	21.8	14:1,165,386	Z:1,856,884	rs14752448	58.1	Z:1,011,410	Z:16,906,523
rs14067572	23.9	14:1,044,618	Z:1,991,048	rs14752726	58.1	Z:1,412,822	Z:17,331,916
rs15001909	23.9	14:850,364	Z:2,194,289	MCW055 ¹	62.3	Z:1,880,642	Z:17,805,556
rs14067279	23.9	14:769,025	Z:2,278,645	rs13676692	62.3	Z:1,973,470	Z:17,922,819
rs15001800	23.9	14:564,920	Z:2,499,360	rs16100280	64.5	Z:3,016,097	Z:19,058,084
rs15001609	23.9	14:62,243	Z:3,017,936	rs14717486	64.5	UN:89,013,853	Z:19,147,167
rs15713281	26.0	14:26,246	Z:3,057,015	rs16014150	64.5	UN:37,961,215	Z:19,222,745
rs14715818	26.0	UN:83,187,257	Z:3,285,118	rs16100452	64.5	Z:3,261,489	Z:19,345,559
rs14711852	26.0	UN:71,607,474	Z:3,286,679	rs16100556	64.5	Z:3,453,168	Z:19,552,965
rs16455399	26.0	4_R:818,184	Z:3,304,358	rs16761631	64.5	Z:3,594,701	Z:19,704,008
rs13820921	26.0	4_R:480,086	Z:3,759,391	rs16100926	64.5	Z:3,979,630	Z:20,112,510
rs16090656	26.0	UN:159,607,500	Z:4,541,646	rs13677045	71.7	Z:4,851,986	Z:21,020,522
rs15249787	26.0	28:2,283,076	Z:5,036,801	rs13677057	71.7	Z:4,943,889	Z:21,118,929
rs15249839	26.0	28:2,390,804	Z:5,181,805	ADL273	89.0	Z:11,070,329	Z:26,113,164
rs14306785	26.0	28:2,449,506	Z:5,250,180	rs16104617	91.1	Z:9,613,748	Z:24,001,916
rs14306843	26.0	28:2,585,904	Z:5,404,539	rs16104549	91.1	Z:9,541,934	Z:24,077,620
rs14689142	26.0	UN:6,772,110	Z:5,767,726	rs14759861	91.1	Z:11,005,733	Z:26,175,862
rs15996532	26.0	UN:7,285,889	Z:6,322,265	rs13776838	93.2	Z_R:112,852	Z:26,589,751
rs14689501	26.0	UN:7,522,379	Z:6,571,869	rs14777222	93.2	Z_R:283,188	Z:26,766,373
rs14742238	26.0	UN:150,762,087	Z:6,798,186	UPS001	93.2	Z_R:606,175	Z:27,109,597
UPS003	32.4	Z_R:7,319,570	Z:7,289,808	rs14777437	93.2	Z_R:622,952	Z:27,127,494
rs14783440	32.4	Z_R:7,428,801	Z:7,411,045	rs14777443	93.2	Z_R:628,210	Z:27,132,752
rs14783496	34.6	Z_R:7,509,732	Z:7,506,577	rs14777636	93.2	Z_R:852,292	Z:27,366,282
rs16779776	38.8	Z_R:7,761,796	Z:7,793,764	rs16008576	93.2	UN:25,433,777	Z:28,322,312
rs16128704	38.8	Z_R:7,797,097	Z:7,835,947	rs16765674	93.2	Z:12,137,305	Z:28,560,394
rs14783808	38.8	Z_R:7,981,254	Z:7,969,686	rs16106682	93.2	Z:12,343,936	Z:28,782,824
rs16129479	45.3	Z_R:8,782,637	Z:8,864,051	rs16071074 ¹	93.2	UN:131,609,645	Z:29,639,884
rs14785652	45.3	Z_R:10,012,011	Z:10,345,543	rs16123676	93.2	Z_R:2,055,888	Z:30,882,703
rs16130939	45.3	Z_R:10,290,280	Z:10,646,509	rs14778400	93.2	Z_R:1,769,891	Z:31,191,750
rs14785975	45.3	Z_R:10,431,957	Z:10,796,625	rs16123428	93.2	Z_R:1,659,175	Z:31,307,855
rs16131190	49.5	Z_R:10,607,056	Z:10,989,801	rs16123209	93.2	Z_R:1,423,240	Z:31,558,700
rs14756180	51.7	Z:6,080,492	Z:12,389,748	rs16108055	93.2	Z:14,502,195	Z:32,471,325
UPS012	51.7	Z_R:14,989,141	Z:12,440,583	rs16026179	93.2	UN:60,609,495	UN:63,183,045
rs16102700	51.7	Z:6,324,688	Z:12,663,377	rs16766257	95.4	Z:13,862,873	Z:33,167,575
rs16102951	51.7	Z:6,544,236	Z:12,906,328	rs16107148	95.4	Z:13,541,159	Z:33,521,002
rs14756702	51.7	Z:6,627,406	Z:12,984,515	rs16765957	95.4	Z:13,221,884	Z:33,857,237
rs14756854 ¹	51.7	Z:6,783,426	Z:13,128,291	rs14722876	101.8	UN:105,446,960	Z:34,555,738
rs16103217 ¹	51.7	Z:6,850,053	Z:13,199,637	rs14764247	101.8	Z:16,411,141	Z:35,306,603
rs16103283	51.7	Z:7,055,128	Z:13,433,889	rs14764322	101.8	Z:16,496,818	Z:35,396,918
				rs14767841	101.8	Z:16,531,722	Z:35,439,558
				rs16110306	101.8	Z:16,924,444	Z:35,869,855
				rs14765130	101.8	Z:17,650,428	Z:36,723,498

rs16768340	101.8 Z:17,852,022	Z:36,935,719	rs14751175	128.8 W:4,180,369	Z:55,190,312
rs14702899	101.8 UN:43,128,032	Z:37,258,524	rs16097183	128.8 W:4,226,761	Z:55,240,702
rs16111451	101.8 Z:18,329,817	Z:37,463,467	rs16096736 ¹	131.0 W:3,754,941	Z:55,849,379
rs13783939	101.8 Z:18,628,876	Z:37,792,194	rs16096662	131.0 W:3,715,941	Z:55,889,311
rs16111717	101.8 Z:18,828,795	Z:38,082,478	rs16096607	131.0 W:3,674,529	Z:55,931,579
rs16131847	101.8 Z_R:11,638,473	Z:38,315,236	rs13798580	131.0 W:3,577,938	Z:56,035,632
rs14786890	101.8 Z_R:11,610,623	Z:38,349,127	rs14750382	131.0 W:3,410,245	Z:56,224,179
rs16131808	101.8 Z_R:11,588,258	Z:38,373,746	rs16096155	131.0 W:3,317,645	Z:56,320,823
rs14719980	101.8 UN:96,235,376	Z:38,480,381	rs16096023	131.0 W:3,237,608	Z:56,403,505
rs14787023	101.8 Z_R:11,890,142	Z:38,669,972	rs14750002	131.0 W:3,125,670	Z:56,520,295
rs16131926	101.8 Z_R:11,895,752	Z:38,675,582	rs13798426	131.0 W:2,835,725	Z:56,828,040
rs14787345	101.8 Z_R:12,524,946	Z:39,348,264	rs16095605	131.0 W:2,584,199	Z:57,093,410
rs16781908	113.9 Z_R:12,694,137	Z:39,529,579	rs16095547	131.0 W:2,459,197	Z:57,220,134
rs16132516	113.9 Z_R:13,229,420	Z:40,102,027	rs16095473	133.1 W:2,278,882	Z:57,415,898
rs16132849	113.9 Z_R:13,846,469	Z:40,795,829	rs16758198	133.1 W:1,462,452	Z:58,438,322
rs16132976	113.9 Z_R:14,137,322	Z:41,089,729	rs16094626	133.1 W:964,778	Z:58,947,438
rs16782623	113.9 Z_R:14,241,895	Z:41,197,379	rs16094539	135.2 W:883,837	Z:59,035,940
rs16133129	113.9 Z_R:14,845,898	Z:41,657,931	rs16094462	135.2 W:726,400	Z:59,200,407
rs16133103	113.9 Z_R:14,558,142	Z:41,950,753	rs16076245	135.2 UN:138,518,078	Z:59,269,270
rs15992814	113.9 UN:3,353,881	Z:42,915,873	rs15998193	135.2 UN:8,540,578	Z:59,329,107
rs16112313	113.9 Z:19,818,850	Z:43,182,096	rs15998133	135.2 UN:8,451,504	Z:59,425,604
rs16111920	113.9 Z:19,289,348	Z:43,764,022	rs13800962	135.2 UN:8,439,010	Z:59,438,098
rs16111918	113.9 Z:19,289,325	Z:43,764,045	rs16119873	135.2 Z:31,185,943	Z:59,841,317
rs16064698	113.9 UN:122,732,772	Z:44,030,846	rs16119736	135.2 Z:31,009,146	Z:60,027,072
rs16040257	113.9 UN:83,973,929	Z:44,190,222	rs16119734	135.2 Z:31,007,220	Z:60,029,798
rs14955912	113.9 10_R:1,390,501	Z:44,827,470	rs16119389	135.2 Z:30,394,833	Z:60,715,472
rs14767668	118.2 Z:23,142,023	UN:14,353,232	rs16119036	135.2 Z:29,893,446	Z:61,281,958
rs14694203	118.2 UN:19,370,246	UN:32,189,462	rs16118916	135.2 Z:29,629,527	Z:61,572,315
rs14015859	118.2 10_R:1,651,519	Z:45,115,164	rs16118632	135.2 Z:29,224,890	Z:62,008,633
rs14016786	118.2 10_R:3,496,080	Z:47,128,465	rs16118052	141.7 Z:28,541,271	UN:40,663,233
rs16083158	118.2 UN:148,057,024	Z:47,544,766	rs16118350	141.7 Z:28,966,502	Z:62,300,901
rs13801352	118.2 UN:10,270,397	Z:47,696,843	rs14772711	141.7 Z:28,844,066	Z:62,428,311
rs16113388	118.2 Z:22,938,801	Z:48,406,834	rs16118199	141.7 Z:28,741,161	Z:62,534,791
rs16769996	118.2 Z:22,863,629	Z:48,495,705	rs16068294	145.9 UN:127,778,958	Z:63,861,610
rs14767266	118.2 Z:22,411,100	Z:48,981,626	rs14775124	145.9 Z:31,765,781	Z:64,245,726
rs16112880	118.2 Z:22,122,667	Z:49,322,809	rs16120489	145.9 Z:31,798,703	Z:64,281,239
rs14708400	118.2 UN:60,052,077	UN:58,331,322	rs16774722 ¹	145.9 Z:32,189,797	Z:64,695,731
rs16112358	120.3 Z:21,477,590	Z:49,994,044	rs14775885 ¹	148.1 Z:32,546,086	Z:65,075,880
rs16113795	120.3 Z:23,633,387	Z:50,465,135	rs16121677	148.1 Z:32,793,305	Z:65,351,510
rs16114049 ¹	120.3 Z:23,883,134	Z:50,733,461	rs16121915	150.2 Z:33,158,281	Z:65,728,779
rs16114279	122.4 Z:24,079,077	Z:50,952,161	rs14776556	150.2 Z:33,306,601	Z:65,890,011
rs16114316	122.4 Z:24,102,344	Z:50,976,658	rs16122099	150.2 Z:33,432,411	Z:66,021,278
rs16114494	122.4 Z:24,306,062	Z:51,210,617	rs16034959	152.3 UN:76,977,623	Z:66,089,477
rs16114675	122.4 Z:24,495,687	Z:51,423,783	rs13817458	152.3 Z:33,545,150	Z:66,320,893
rs16115031	122.4 Z:24,898,443	Z:51,852,759	rs16776886	154.5 Z_R:2,650,489	Z:66,834,935
rs16115428	126.7 Z:25,457,890	Z:52,459,183	UPS004	154.5 Z_R:2,745,888	Z:66,936,257
rs16115888	126.7 Z:25,985,204	Z:53,041,087	rs16124385	154.5 Z_R:2,746,017	Z:66,936,386
rs16116207	126.7 Z:26,426,882	Z:53,504,392	rs14736553	154.5 UN:137,789,867	Z:68,095,620
rs16116653	126.7 Z:26,830,473	Z:53,942,031	rs16125413	158.7 Z_R:4,352,251	Z:68,724,450
rs14770890	126.7 Z:26,852,116	Z:53,966,934	rs14781095	158.7 Z_R:5,015,512	Z:69,477,833
rs16116788	126.7 Z:27,066,524	Z:54,206,112	rs14781227	158.7 Z_R:5,171,264	Z:69,636,649
rs16097757	128.8 W:4,785,778	Z:54,714,017	UPS005	158.7 Z_R:5,721,557	Z:70,219,051
rs16097670	128.8 W:4,695,319	Z:54,815,295	rs16127597	158.7 Z_R:6,607,882	Z:71,175,863
rs16096956	128.8 W:4,008,757	Z:55,003,897	rs14782675 ¹	158.7 Z_R:6,636,727	Z:71,205,876
rs14751139 ¹	128.8 W:4,106,833	Z:55,107,396	rs16127903	158.7 Z_R:6,897,679	Z:71,491,613

rs15991767	162.1 UN:1,999,135	Z:73,147,457
rs14684801	179.1 UN:1,058,010	Z:73,657,364
rs15990837	185.5 UN:1,148,163	Z:73,750,193
rs15990878	185.5 UN:1,163,078	Z:73,765,057
rs15991270	200.9 UN:1,460,928	Z:74,084,935

¹Markers that initially could not unambiguously be placed in a single bin in the map, and have been moved to the most likely position according to the chicken assembly of May 2006.

Supplementary Table 3. Markers assigned to the Z chromosome only based on the observation of 10 heterozygous males and no heterozygous females. The markers are sorted after their position (in base pair) in the May 2006 assembly and the location in the February 2004 assembly is also given.

Marker	Genome assembly position				
	February 2004 Chr:position	May 2006 Chr:position			
rs14688321	UN:5,187,142	Z:231,490	rs16781857	Z_R:12,482,057	Z:39,304,292
rs14687646	UN:4,523,913	Z:950,318	rs14787542	Z_R:12,827,686	Z:39,669,592
rs14067214	14:686,803	Z:2,372,042	rs14955912	10_R:1,390,501	Z:44,827,469
rs14067088	14:485,288	Z:2,584,821	rs14956052	10_R:1,621,877	Z:45,072,689
rs15001632	14:165,312	Z:2,908,384	rs14015859	10_R:1,651,519	Z:45,115,163
rs15648873	4_R:992,867	Z:3,112,867	rs14015865	10_R:1,659,274	Z:45,123,488
rs16007804	UN:23,971,035	Z:3,253,130	rs14956486	10_R:2,916,361	Z:46,494,303
rs16455399	4_R:818,184	Z:3,304,357	rs14016786	10_R:3,496,080	Z:47,128,464
rs14507318	4_R:677,825	Z:3,530,872	rs14716126	UN:84,070,275	Z:47,515,460
rs13820921	4_R:480,086	Z:3,759,390	rs14767471	Z:22,655,952	Z:48,722,748
rs15648610	4_R:349,694	Z:3,902,899	rs14766378	Z:21,454,227	Z:50,016,563
rs14689221	UN:6,909,413	Z:5,921,776	rs14769506	Z:25,163,615	Z:52,149,216
rs15996532	UN:7,285,889	Z:6,322,264	rs14769569	Z:25,205,122	Z:52,192,567
rs14689521	UN:7,576,521	Z:6,629,452	rs16115994	Z:26,096,534	Z:53,164,169
rs14783113	Z_R:7,030,114	Z:6,955,086	rs14738904	UN:142,707,343	Z:54,630,986
rs16780115	Z_R:8,404,037	Z:8,433,041	rs16097497	W:4,458,980	Z:55,488,332
rs16006093	UN:21,617,030	Z:9,442,791	rs16095859	W:3,118,236	Z:56,527,175
rs14785567	Z_R:9,908,079	Z:10,105,929	rs13798440	W:3,011,514	Z:56,634,657
rs14786714	Z_R:11,265,313	Z:11,683,674	rs14749412	W:1,954,301	Z:57,764,664
rs16102307	Z:5,644,633	Z:11,934,800	rs16095065	W:1,722,147	Z:58,156,750
rs14710122	UN:65,463,690	Z:14,120,331	rs14749197	W:1,642,026	Z:58,246,907
rs16098366	Z:241,168	Z:16,109,238	rs14748908	W:1,314,034	Z:58,596,932
rs16099588	Z:2,191,676	Z:18,161,143	rs15998133	UN:8,451,504	Z:59,425,603
rs16101107	Z:4,278,927	Z:20,419,728	rs13800962	UN:8,439,010	Z:59,438,097
rs15001520	13_R:1,031,272	Z:21,826,757	rs14690039	UN:8,297,197	Z:59,590,332
rs15001385	13_R:698,534	Z:22,182,498	rs14774661	Z:31,378,685	Z:59,629,026
rs14066341	13_R:641,272	Z:22,242,378	rs14773641	Z:29,913,860	Z:61,260,759
rs13788432	13_R:410,483	Z:22,487,127	rs14773440	Z:29,587,220	Z:61,618,781
rs13788418	13_R:253,603	Z:22,661,285	rs14773275	Z:29,388,215	Z:61,832,447
rs14759638	Z:10,699,173	Z:22,834,423	rs14773077	Z:29,168,152	Z:62,071,419
rs16105339	Z:10,309,927	Z:23,266,972	rs14772105	Z:28,339,371	Z:62,867,847
rs16105163	Z:10,119,232	Z:23,465,961	rs16117595	Z:28,095,270	Z:63,137,428
rs16105146	Z:10,099,613	Z:23,486,670	rs14771350	Z:27,594,287	Z:63,676,573
rs16106040	Z:11,323,731	Z:25,840,646	rs14774895	Z:31,582,281	Z:64,058,149
rs14777366	Z_R:520,247	Z:27,020,702	rs16121860	Z:32,997,820	Z:65,566,461
rs16080645	UN:143,710,881	Z:30,097,595	rs14693451	UN:17,073,542	Z:66,269,794
rs14706826	UN:55,575,251	Z:31,044,162	rs16126516	Z_R:5,406,861	Z:69,887,131
rs14762832	Z:15,081,597	Z:31,855,782	rs13725663	Z_R:5,659,678	Z:70,155,554
rs14763234	Z:15,473,028	Z:34,279,091	rs14782219	Z_R:6,311,411	Z:70,865,512
rs14763396	Z:15,626,672	Z:34,451,583	rs14686246	UN:2,739,544	Z:71,979,376
rs16109534	Z:15,806,260	Z:34,663,498	rs14686603	UN:3,047,172	Z:72,310,603
rs14764176	Z:16,330,176	Z:35,221,398	rs15992691	UN:3,068,072	Z:72,331,306
rs14764487	Z:16,811,032	Z:35,739,163	rs15992084	UN:2,576,439	Z:72,543,573
rs14739816	UN:144,494,303	Z:35,945,289	rs15991978	UN:2,318,177	Z:72,805,239
			rs14685710	UN:2,109,080	Z:73,028,601
			rs15990837	UN:1,148,163	Z:73,750,192
			rs14685087	UN:1,347,798	Z:73,969,607

rs14685395 UN:1,677,754 Z:74,317,242
rs15168793 2:147,518,337 Z:74,508,147
rs14506962 4_R:35,872 UN:32,660,578
rs14741634 UN:149,308,745 UN:39,463,393

rs13816158 UN:153,613,376 UN:60,318,363
rs14708001 UN:58,886,668 UN:60,804,383
rs14692484 UN:13,799,153 UN:9,861,559

Supplementary Table 4. Summary of markers assigned to chicken chromosome Z in relation to their location on the genome assembly (February 2004). The type of evidence for the assignment (linkage analysis and/or genotype distribution analysis) is indicated. Markers had to show • ten heterozygous males and no heterozygous females to be considered as Z-linked by genotype analysis.

Previous assignment	Number of loci		
	Total	Linkage	Genotype
Z	117	87	30
Z_Random	55	45	10
W	29	22	7
Unknown	69	39	30
2	1	-	1
4_Random	8	2	6
10_Random	9	3	6
13_Random	5	-	5
14	11	8	3
28	4	4	-
Total	308	210	98

