

Data analysis: Composite interval mapping

Azam et al.

Interval mapping

Plant maturity

```
library(diaQTL)
library(ggplot2)
library(ggpubr)
```

```
convert_polyorigin(filename = "outstem_IM_polyancestry.csv", mapfile = NULL,
  remove.outliers = TRUE, outstem = "FileS8_" )
```

```
# Plant maturity
```

```
data_pm <- read_data(genofile = "FileS8_diaQTL_genofile.csv",
  ploidy = 4,
  pedfile = "FileS8_diaQTL_pedfile.csv",
  phenofile = "FileS9.csv",
  bin.markers = TRUE,
  n.core = 6)
```

```
set_params(data_pm, trait = "Plant.maturity", q=0.5, r=0.1)
```

```
##          burnIn nIter
## additive    14   438
## residual     2   105
```

```
get_map(data_pm)
```

```
##      chrom Morgans
## 1         1    1.24
## 2         2    0.81
## 3         3    1.11
## 4         4    0.90
## 5         5    1.21
## 6         6    0.83
## 7         7    0.83
## 8         8    1.00
## 9         9    0.92
## 10        10    0.81
## 11        11    0.79
## 12        12    0.95
## 13 total:   11.39
```

```
alpha.05_add <- DIC_thresh(genome.size=11.39,num.parents=3,
                           ploidy=4,alpha=0.05, dominance = 1)
alpha.1_add <- DIC_thresh(genome.size=11.39,num.parents=3,
                          ploidy=4,alpha=0.1, dominance = 1)
```

```
##Discovery with additive model:
```

```
ans1 <- scan1(data = data_pm,
              trait = "Plant.maturity",
              params = list(burnIn=50,nIter=1000),
              n.core = 4)
```

```
##Discovery with digenic dominance model:
```

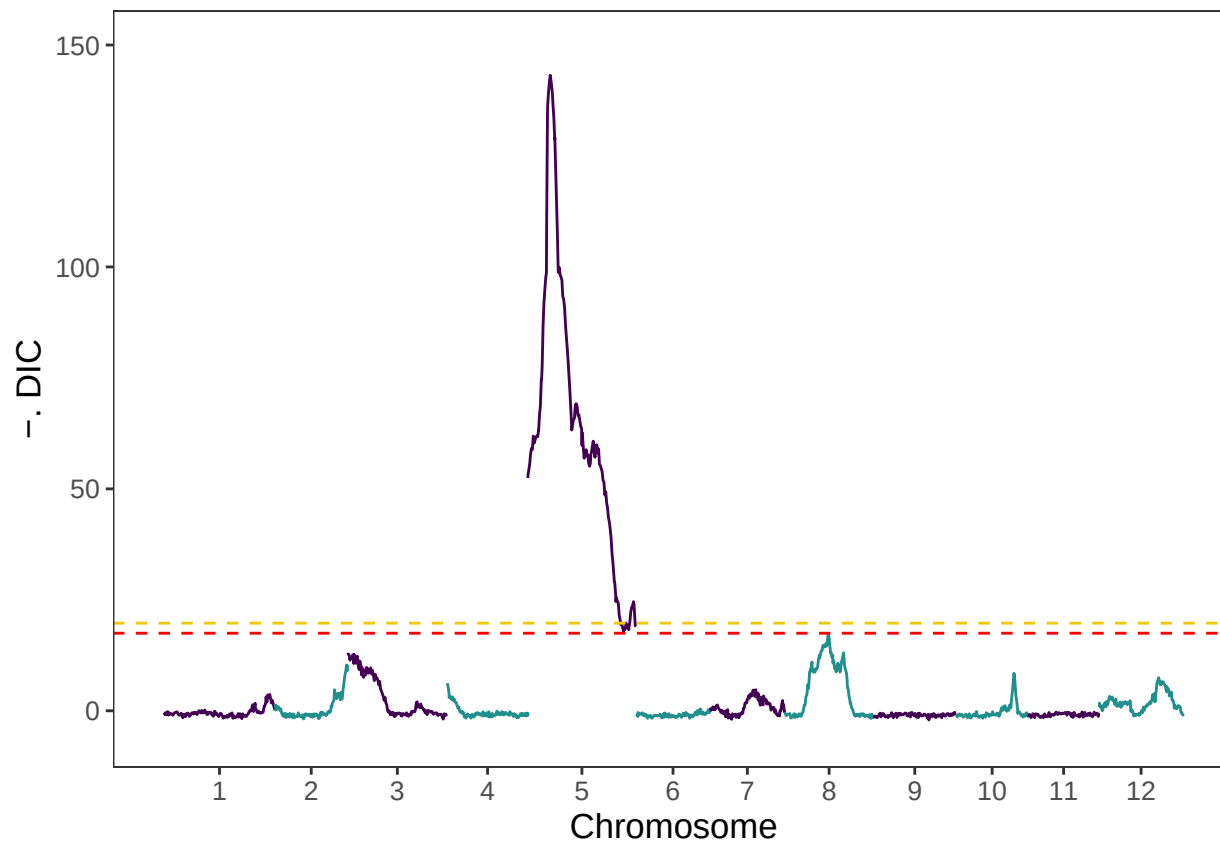
```
ans2 <- scan1(data = data_pm,
              trait = "Plant.maturity",
              params = list(burnIn=50,nIter=1000),
              dominance = 2,
              n.core = 4)
```

```
ans1.summary <- scan1_summary(ans1, position="cM")
ans1.summary$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 1518	C1_34_1	1	118.24	-475.3790	-3.6798367
## 2679	C2_31_1	2	81.01	-472.4099	-10.4007561
## 2686	chr3.1.1	3	1.00	-471.5089	-12.8136172
## 4119	C4_1_1	4	0.00	-473.7206	-6.2050361
## 5634	chr5.25.1	5	25.00	-403.2014	-143.1764735
## 7803	chr6.72.1	6	72.00	-476.6237	-0.4281151
## 8626	chr7.51.1	7	51.00	-475.0749	-4.7364864
## 9680	C8_9_1	8	48.82	-468.6128	-17.4053985
## 10919	C9_13_1	9	42.65	-478.5776	0.3380977
## 12390	chr10.65.1	10	65.00	-472.7027	-8.4480740
## 13393	chr11.60.1	11	60.00	-478.5163	0.2577371
## 14518	chr12.67.1	12	67.00	-473.5318	-7.4600604

```
p1 <- ans1.summary$plot + geom_hline(yintercept=alpha.05_add,color="gold2",linetype=2) +
  geom_hline(yintercept=alpha.1_add,color="red",linetype=2) + ylim(-5,150)
```

```
p1
```



```
BayesCI(ans1,data_pm,chrom="5",CI.prob=0.9)
```

```
##      marker chrom    cM      LL  deltaDIC
## 5593 C5_5_1      5 21.91 -407.7874 -134.9129
## 5675 C5_6_6      5 27.55 -406.0197 -138.5746
```

```
ans2.summary <- scan1_summary(ans2, position="cM")
ans2.summary$peaks
```

```
##      marker chrom    cM      LL  deltaDIC
## 840   chr1.67.1    1 67.00 -467.0109  -6.6002000
## 1638  chr2.3.1     2  3.00 -470.0680  -2.2371609
## 2750  chr3.6.1     3  6.00 -462.4098 -17.2263381
## 4216  chr4.8.1     4  8.00 -467.1987  -7.9721785
## 5646  chr5.26.1    5 26.00 -397.6879 -143.1982345
## 7949   C6_28_4     6 82.98 -470.5881  -0.5146689
## 8888  chr7.71.1    7 71.00 -465.6670 -10.9701577
## 9680   C8_9_1      8 48.82 -467.7759 -10.0531980
## 10369  C9_1_1      9  0.00 -467.1497  -6.0132636
## 12387  C10_15_1    10 64.84 -468.0332  -7.0955258
## 13369 chr11.58.1   11 58.00 -476.0354   5.6177932
## 13886 chr12.19.1   12 19.00 -466.2365  -9.6808292
```

We continue with the additive model as difference between the DIC is not equal to or greater than 10.

```
##Composite interval mapping (CIM)
```

```
qtl.5at25 <- ans1.summary$peaks$marker[5]
```

```
covariate <- data.frame(marker = qtl.5at25, dominance = c(1), epistasis = c(FALSE))
```

```
ans1_CIM <- scan1(data = data_pm,  
  trait = "Plant.maturity",  
  params = list(burnIn=50,nIter=1000),  
  covariate = covariate,  
  dominance = 1,  
  n.core = 6)
```

```
ans1_CIM.summary <- scan1_summary(ans1_CIM, position="cM")
```

```
ans1_CIM.summary$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 636	chr1.51.1	1	51.00	-398.1096	-7.935774
## 2679	C2_31_1	2	81.01	-397.4567	-8.019810
## 2781	chr3.8.1	3	8.00	-399.9848	-1.937988
## 4252	chr4.11.1	4	11.00	-396.4732	-8.015393
## 6825	C5_22_1	5	118.55	-396.7734	-9.797294
## 7827	chr6.74.1	6	74.00	-400.2463	-1.536040
## 8358	C7_10_1	7	31.22	-397.0988	-6.731782
## 9708	C8_10_1	8	50.61	-396.0391	-11.055944
## 10676	chr9.24.1	9	24.00	-399.5090	-4.829240
## 12387	C10_15_1	10	64.84	-398.3293	-4.291666
## 13004	chr11.31.1	11	31.00	-400.3396	-1.879293
## 14506	chr12.66.1	12	66.00	-397.6919	-9.658299

With CIM, we did not find any additional QTL that passed the DIC threshold at $\alpha=0.05$.

```
params <- list(burnIn=1000,nIter=10000)
```

```
fitqtl.5at25 <- fitQTL(data = data_pm, trait = "Plant.maturity", params = params,  
  qtl = data.frame(marker=qtl.5at25,dominance=1))
```

```
fitqtl.5at25.POL <- fitQTL(data = data_pm, trait = "Plant.maturity", params = params,  
  qtl = data.frame(marker=qtl.5at25,dominance=1), polygenic = TRUE)
```

```
fitqtl.5at25$deltaDIC
```

```
## [1] -142.8568
```

```
fitqtl.5at25.POL$deltaDIC
```

```
## [1] -167.3651
```

We accept the model that includes polygenic effect and the DIC is lowered by at least 10 points.

```
fitqtl.5at25$var
```

```
##               Mean CI.lower CI.upper
## chr5.25.1 additive 0.29      0.24      0.35
## residual          0.71      0.65      0.76
```

```
fitqtl.5at25.POL$var
```

```
##               Mean CI.lower CI.upper
## chr5.25.1 additive 0.27      0.21      0.34
## polygenic          0.20      0.12      0.30
## residual          0.52      0.43      0.61
```

Additive effects of parental haplotypes in the multi-QTL model for plant maturity.

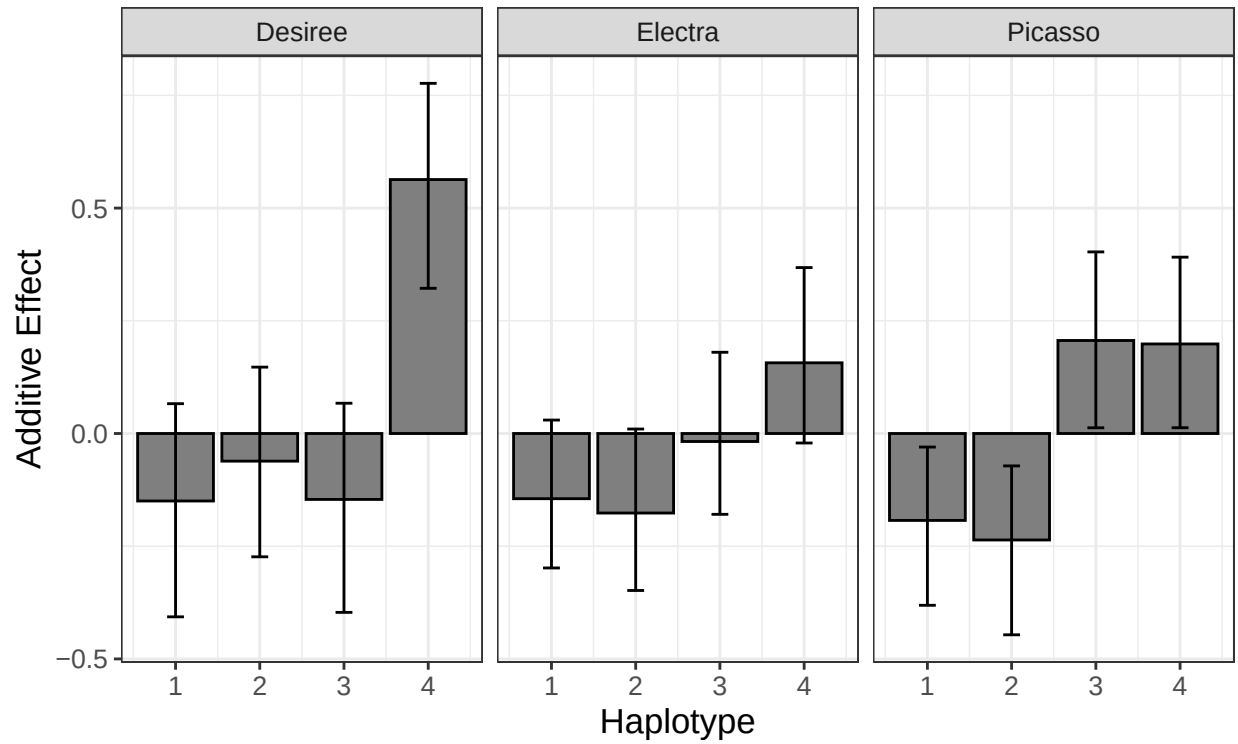
```
fitqtl.5at25.POL$plots$chr5.25.1$additive$data
```

```
##           parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.14973591 -0.40663697 0.066109133
## Desiree.2 Desiree 2 -0.06126944 -0.27354166 0.147198059
## Desiree.3 Desiree 3 -0.14623985 -0.39678223 0.067116263
## Desiree.4 Desiree 4  0.56327505  0.32206992 0.776698810
## Electra.1 Electra 1 -0.14460571 -0.29826899 0.029816073
## Electra.2 Electra 2 -0.17645266 -0.34821672 0.009958049
## Electra.3 Electra 3 -0.01776730 -0.17929674 0.180149765
## Electra.4 Electra 4  0.15682689 -0.02107780 0.368031197
## Picasso.1 Picasso 1 -0.19275254 -0.38103945 -0.030050188
## Picasso.2 Picasso 2 -0.23621751 -0.44655813 -0.071893436
## Picasso.3 Picasso 3  0.20633711  0.01266369 0.402779998
## Picasso.4 Picasso 4  0.19860187  0.01278869 0.391127832
```

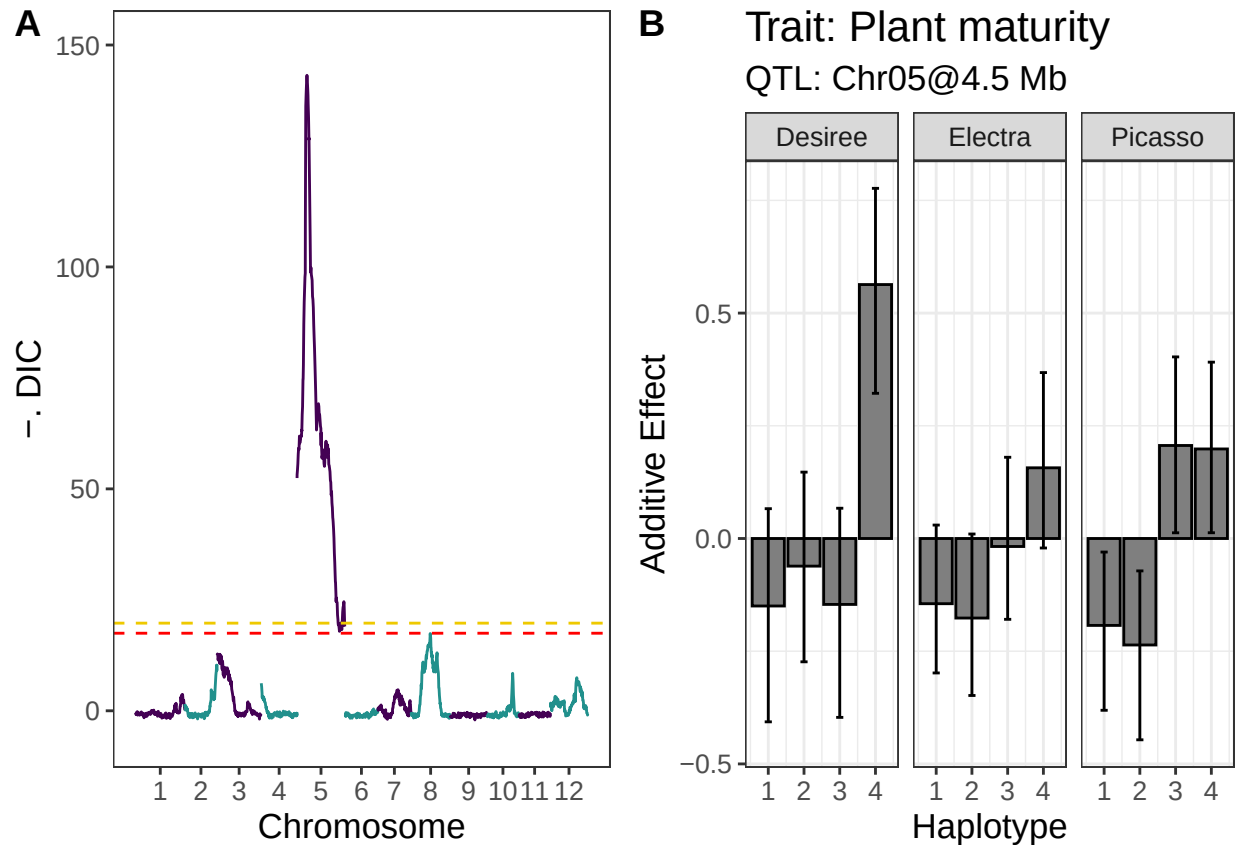
```
p2 <- fitqtl.5at25.POL$plots$chr5.25.1$additive
```

```
p2$labels$title <-"Trait: Plant maturity"
p2$labels$subtitle <-"QTL: Chr05@4.5 Mb"
p2
```

Trait: Plant maturity
QTL: Chr05@4.5 Mb



```
ggarrange(p1,p2, labels = c("A","B"))
```



```
ggsave("FigureS10.png",device="png",dpi=600,height=3.5,width=9)
```

Tuber shape

```
data_ts <- read_data(genofile = "FileS8_diaQTL_genofile.csv",
  ploidy = 4,
  pedfile = "FileS8_diaQTL_pedfile.csv",
  phenofile = "FileS10.csv",
  bin.markers = TRUE,
  n.core = 6)
```

```
set_params(data_ts, trait = "Tuber.shape", q=0.5, r=0.1)
```

```
##          burnIn nIter
## additive      30   970
## residual       2   102
```

```
##Discovery with additive model:
```

```
ans1 <- scan1(data = data_ts,
  trait = "Tuber.shape",
  params = list(burnIn=50,nIter=1500),
```

```

n.core = 4)

##Discovery with digenic dominance model:

ans2 <- scan1(data = data_ts,
  trait = "Tuber.shape",
  params = list(burnIn=50,nIter=1500),
  dominance = 2,
  n.core = 4)

```

```

ans1.summary <- scan1_summary(ans1, position="cM")
ans1.summary$peaks

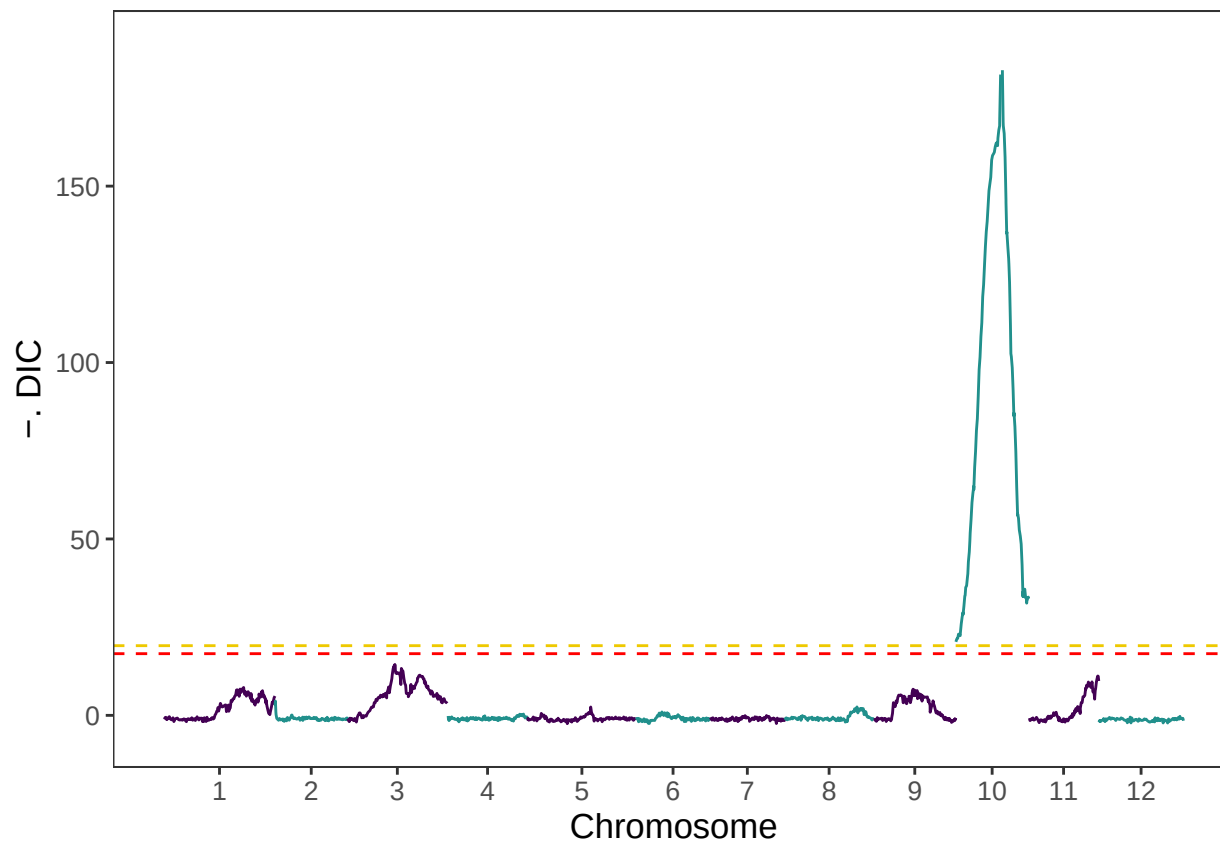
```

##	marker	chrom	cM	LL	deltaDIC
## 1115	chr1.89.1	1	89.00	-552.2855	-7.89579595
## 1605	C2_1_3	2	0.45	-554.8820	-4.05360668
## 3351	chr3.53.1	3	53.00	-549.3433	-14.41956133
## 5253	C4_33_1	4	85.22	-557.3246	-0.36600644
## 6208	C5_11_2	5	70.24	-555.4188	-2.36436490
## 7226	C6_8_1	6	29.02	-555.0494	-0.97025310
## 8787	chr7.63.1	7	63.00	-556.7762	0.05042331
## 10128	chr8.81.1	8	81.00	-555.1275	-2.39110576
## 10936	chr9.44.1	9	44.00	-552.8665	-7.41326087
## 12201	chr10.51.1	10	51.00	-460.7227	-190.41671403
## 13630	C11_21_1	11	77.39	-549.2868	-11.14675304
## 14824	C12_22_1	12	90.73	-556.8783	0.28279738

```

p1 <- ans1.summary$plot + geom_hline(yintercept=alpha.05_add,color="gold2",linetype=2) +
  geom_hline(yintercept=alpha.1_add,color="red",linetype=2) + ylim(-5,190)
p1

```

```
BayesCI(ans1,data_ts,chrom="10",CI.prob=0.9)
```

```
##           marker chrom cM      LL deltaDIC
## 12175  chr10.49.1    10 49 -471.5581 -169.2512
## 12224 chr10.52.12    10 52 -464.5955 -182.8586
```

```
ans2.summary <- scan1_summary(ans2, position="cM")
ans2.summary$peaks
```

```
##           marker chrom    cM      LL      deltaDIC
## 1382  chr1.109.1     1 109.00 -547.8920  -6.5642117
## 2005   chr2.31.1     2  31.00 -552.5899   2.2401953
## 3935   chr3.97.1     3  97.00 -545.2055 -10.8595173
## 5273   chr4.87.1     4  87.00 -551.0973   1.2951154
## 6123   chr5.64.1     5  64.00 -548.7685  -5.4067490
## 7214   chr6.29.1     6  29.00 -552.1360   0.8290483
## 8997   chr7.79.1     7  79.00 -553.1258   2.7322778
## 10100  chr8.79.1     8  79.00 -548.2630  -5.9382400
## 10733  chr9.28.1     9  28.00 -546.1763  -9.0267004
## 12199   C10_9_1    10  50.98 -459.4972 -182.4518707
## 13639 chr11.78.1    11  78.00 -540.9948 -16.5967160
## 14824  C12_22_1    12  90.73 -553.8374   2.5219577
```

We continue with the additive model as difference between the DIC is not equal to or greater than 10.

```
##Composite interval mapping (CIM)
```

```
qtl.10at51 <- ans1.summary$peaks$marker[10]
```

```
covariate <- data.frame(marker = qtl.10at51, dominance = c(1), epistasis = c(FALSE))
```

```
ans1_CIM <- scan1(data = data_ts,  
  trait = "Tuber.shape",  
  params = list(burnIn=50,nIter=1000),  
  covariate = covariate,  
  dominance = 1,  
  n.core = 6)
```

```
ans1_CIM.summary <- scan1_summary(ans1_CIM, position="cM")
```

```
ans1_CIM.summary$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 1027	chr1.82.1	1	82.00	-453.2054	-9.8378572
## 1603	C2_1_1	2	0.00	-454.4977	-5.4646914
## 3844	C3_28_1	3	89.92	-450.2432	-17.2714921
## 4548	chr4.33.1	4	33.00	-459.5272	0.9986944
## 5400	C5_2_1	5	6.93	-459.6387	1.1224550
## 6880	C6_2_1	6	2.13	-452.2537	-7.9818026
## 8775	chr7.62.1	7	62.00	-457.8831	-1.2919445
## 10083	chr8.78.1	8	78.00	-457.5875	-2.9593795
## 11138	chr9.60.1	9	60.00	-455.3606	-3.1090181
## 12199	C10_9_1	10	50.98	-460.8502	1.2992762
## 12966	chr11.28.1	11	28.00	-453.1585	-8.5485495
## 14315	chr12.52.1	12	52.00	-456.9383	-1.8461164

With CIM, we did not find any additional QTL that passed the DIC threshold at $\alpha=0.05$.

```
params <- list(burnIn=1000,nIter=10000)
```

```
fitqtl.10at51.1 <- fitQTL(data = data_ts, trait = "Tuber.shape", params = params,  
  qtl = data.frame(marker=qtl.10at51,dominance=1))  
fitqtl.10at51.POL <- fitQTL(data = data_ts, trait = "Tuber.shape", params = params,  
  qtl = data.frame(marker=qtl.10at51,dominance=1), polygenic = TRUE)
```

```
fitqtl.10at51$deltaDIC
```

```
## [1] -190.2998
```

```
fitqtl.10at51.POL$deltaDIC
```

```
## [1] -241.1284
```

We accept the model that includes polygenic effect and the DIC is lowered by at least 10 points.

```
fitqtl.10at51$var
```

```
##                Mean CI.lower CI.upper
## chr10.51.1 additive 0.36      0.30      0.41
## residual           0.64      0.59      0.70
```

```
fitqtl.10at51.POL$var
```

```
##                Mean CI.lower CI.upper
## chr10.51.1 additive 0.31      0.25      0.36
## polygenic           0.28      0.18      0.39
## residual            0.41      0.33      0.49
```

```
### Additive effects of parental haplotypes in the single-QTL model for tuber shape.
```

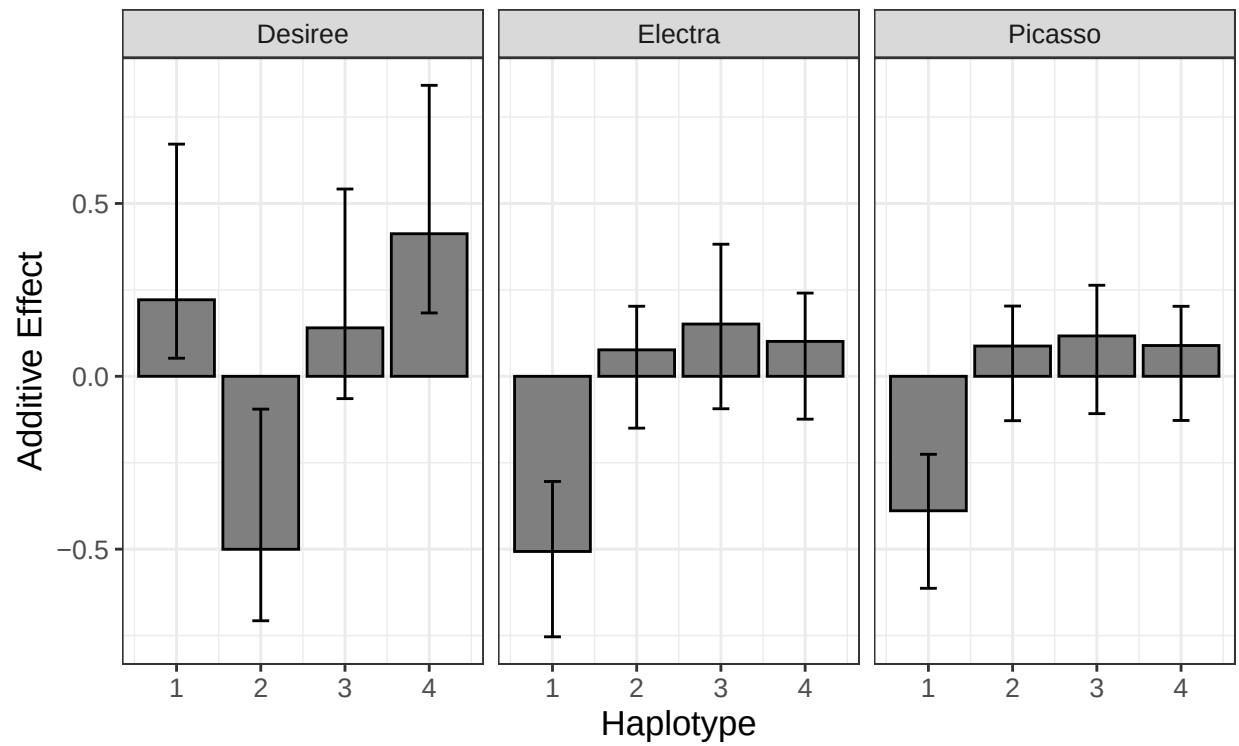
```
fitqtl.10at51.POL$plots$chr10.51.1$additive$data
```

```
##          parent x          mean    CI.lower    CI.upper
## Desiree.1 Desiree 1  0.22141305  0.05232507  0.67164157
## Desiree.2 Desiree 2 -0.50043600 -0.70716509 -0.09495992
## Desiree.3 Desiree 3  0.14020962 -0.06458305  0.54176622
## Desiree.4 Desiree 4  0.41243093  0.18331462  0.84175814
## Electra.1 Electra 1 -0.50672828 -0.75364181 -0.30422823
## Electra.2 Electra 2  0.07649222 -0.14992280  0.20264233
## Electra.3 Electra 3  0.15121737 -0.09383918  0.38213506
## Electra.4 Electra 4  0.10094622 -0.12396185  0.24080434
## Picasso.1 Picasso 1 -0.38902013 -0.61328027 -0.22563883
## Picasso.2 Picasso 2  0.08758775 -0.12846257  0.20319850
## Picasso.3 Picasso 3  0.11682078 -0.10797778  0.26338138
## Picasso.4 Picasso 4  0.08906647 -0.12769548  0.20254384
```

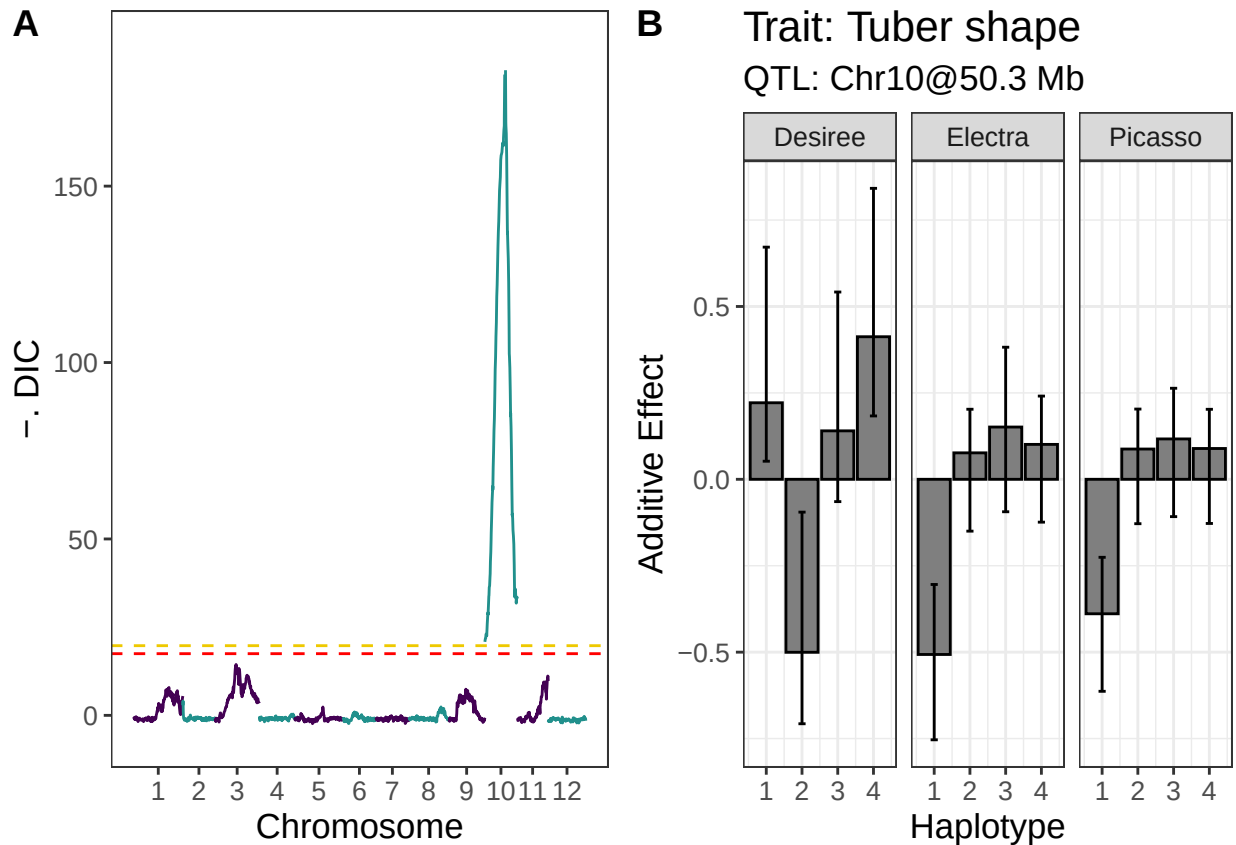
```
p2 <- fitqtl.10at51.POL$plots$chr10.51.1$additive
```

```
p2$labels$title <-"Trait: Tuber shape"
p2$labels$subtitle <-"QTL: Chr10@50.3 Mb"
p2
```

Trait: Tuber shape
QTL: Chr10@50.3 Mb



```
ggarrange(p1,p2, labels = c("A","B"))
```



```
ggsave("FigureS11.png",device="png",dpi=600,height=3.5,width=9)
```

Common scab

```
data_cs <- read_data(genofile = "FileS8_diaQTL_genofile.csv",
  ploidy = 4,
  pedfile = "FileS8_diaQTL_pedfile.csv",
  phenofile = "FileS7.csv",
  fixed = "env",
  bin.markers = TRUE,
  n.core = 6)
```

```
set_params(data_cs, trait = "Common.scab", q=0.5, r=0.1)
```

```
##          burnIn nIter
## additive    16   520
## residual     2   100
```

```
alpha.05_dom <- DIC_thresh(genome.size=11.39,num.parents=3,
  ploidy=4,alpha=0.05, dominance = 2)
alpha.1_dom <- DIC_thresh(genome.size=11.39,num.parents=3,
  ploidy=4,alpha=0.1, dominance = 2)
```

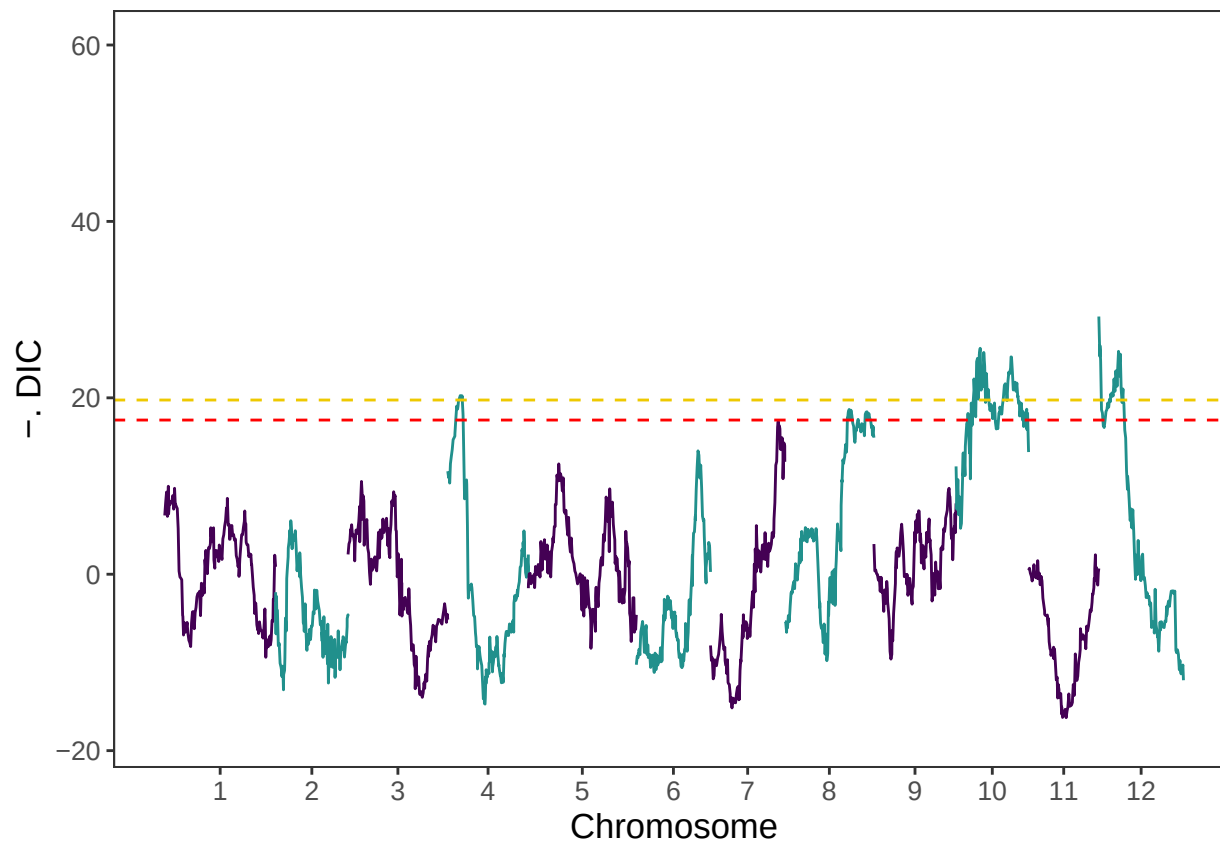
```
##Discovery with additive model:
```

```
ans1 <- scan1(data = data_cs,  
              trait = "Common.scab",  
              params = list(burnIn=50,nIter=1000),  
              n.core = 6)
```

```
ans1.summary <- scan1_summary(ans1, position="cM")  
ans1.summary$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 39	chr1.4.1	1	4.00	-2878.204	-9.972481
## 1831	chr2.17.1	2	17.00	-2884.055	-6.066769
## 2869	chr3.15.1	3	15.00	-2879.293	-10.517376
## 4294	chr4.14.1	4	14.00	-2877.178	-20.254528
## 5755	chr5.34.1	5	34.00	-2877.805	-12.508888
## 7764	chr6.69.1	6	69.00	-2876.697	-13.988840
## 8948	C7_26_2	7	75.69	-2878.163	-17.325655
## 10008	chr8.72.1	8	72.00	-2876.970	-18.679872
## 11455	chr9.84.1	9	84.00	-2879.713	-9.744383
## 11906	chr10.27.1	10	27.00	-2871.728	-25.617244
## 13589	C11_20_1	11	74.74	-2883.316	-2.204861
## 13653	C12_1_1	12	0.00	-2869.283	-29.217094

```
p1.A <- ans1.summary$plot + geom_hline(yintercept=alpha.05_add,color="gold2",linetype=2)+  
  geom_hline(yintercept=alpha.1_add,color="red",linetype=2) + ylim(-18,60)  
p1.A
```



```
##Composite interval mapping (CIM)
```

```
qtl.4at14 <- ans1.summary$peaks$marker[4]
qtl.10at27 <- ans1.summary$peaks$marker[10]
qtl.12at0 <- ans1.summary$peaks$marker[12]

covariate <- data.frame(marker = c(qtl.4at14,qtl.10at27,qtl.12at0),
                        dominance = 1, epistasis = FALSE)

chr <- data.frame(chr = c(4,10,12))

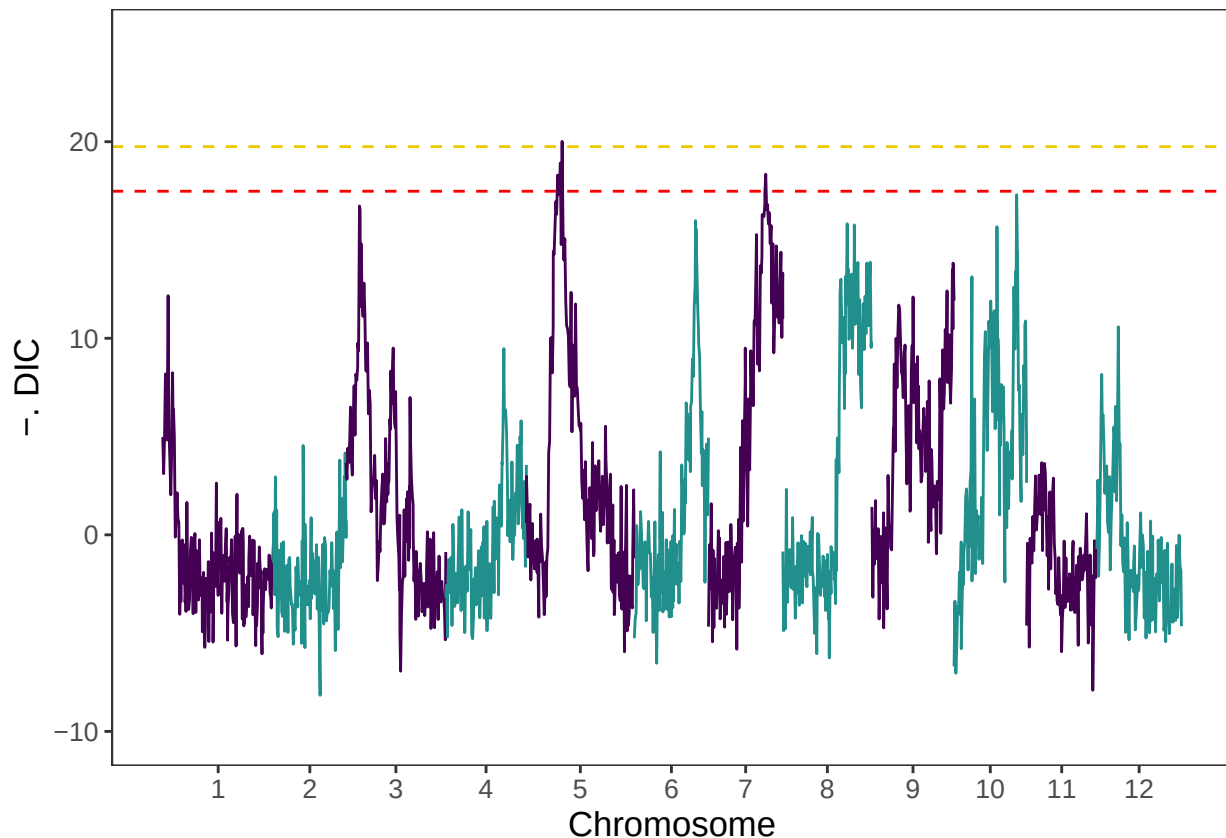
ans1_CIM <- scan1(data = data_cs,
                 trait = "Common.scab",
                 params = list(burnIn=50,nIter=1000),
                 covariate = covariate,
                 dominance = 1,
                 n.core = 4)
```

```
ans1_CIM.summ <- scan1_summary(ans1_CIM, position="cM")
ans1_CIM.summ$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 69	chr1.6.1	1	6.00	-2831.136	-12.166006
## 2036	chr2.33.1	2	33.00	-2837.121	-4.541261
## 2869	chr3.15.1	3	15.00	-2827.304	-16.730517

```
## 4986   chr4.65.1      4 65.00 -2831.050  -9.471664
## 5827   chr5.40.1      5 40.00 -2828.268 -20.015710
## 7758    C6_24_1       6 68.50 -2829.477 -15.984187
## 8803   chr7.64.1      7 64.00 -2828.199 -18.347083
## 10008  chr8.72.1      8 72.00 -2829.317 -15.825021
## 11549   C9_27_6       9 90.75 -2827.926 -13.823296
## 12454  chr10.70.1     10 70.00 -2828.185 -17.299735
## 12817  chr11.17.1     11 17.00 -2833.620  -3.669613
## 13953  chr12.24.1     12 24.00 -2832.767 -10.585009
```

```
p2.A <- ans1_CIM.summ$plot +
  geom_hline(yintercept=alpha.05_add,color="gold2",linetype=2) +
  geom_hline(yintercept=alpha.1_add,color="red",linetype=2) +
  ylim(-10,25)
p2.A
```



With CIM, we found an additional QTL on chr 5.

```
qtl.5at40 <- ans1_all.summ$peaks$marker[5]

chr <- data.frame(chr = c(4,5,10,12))

covariate <- data.frame(marker = c(qtl.4at14,qtl.5at40,qtl.10at27,qtl.12at0),
  dominance = 1, epistasis = FALSE)

##QTL refinement
```



```

refine.1 <- NULL
ans1_refine <- vector("list", 4)

for(i in 1:4){
  ans1_refine[[i]] <- scan1(data = data_cs,
    trait = "Common.scab",
    params = list(burnIn=50,nIter=1000),
    covariate = covariate[-i,],
    chrom = chr[i,],
    dominance = 1,
    n.core = 4)
  refine.1 <- rbind(refine.1,ans1_refine[[i]])
}

```

```

refine.1_summ <- scan1_summary(refine.1, position="cM")

refine.1_summ$peaks

```

```

##           marker chrom    cM      LL  deltaDIC
## 4294   chr4.14.1     4 14.00 -2828.173 -14.51289
## 5755   chr5.34.1     5 34.00 -2828.402 -18.73287
## 11930 chr10.29.1    10 29.00 -2828.421 -31.58905
## 13670   C12_2_2    12  1.23 -2829.016 -47.87200

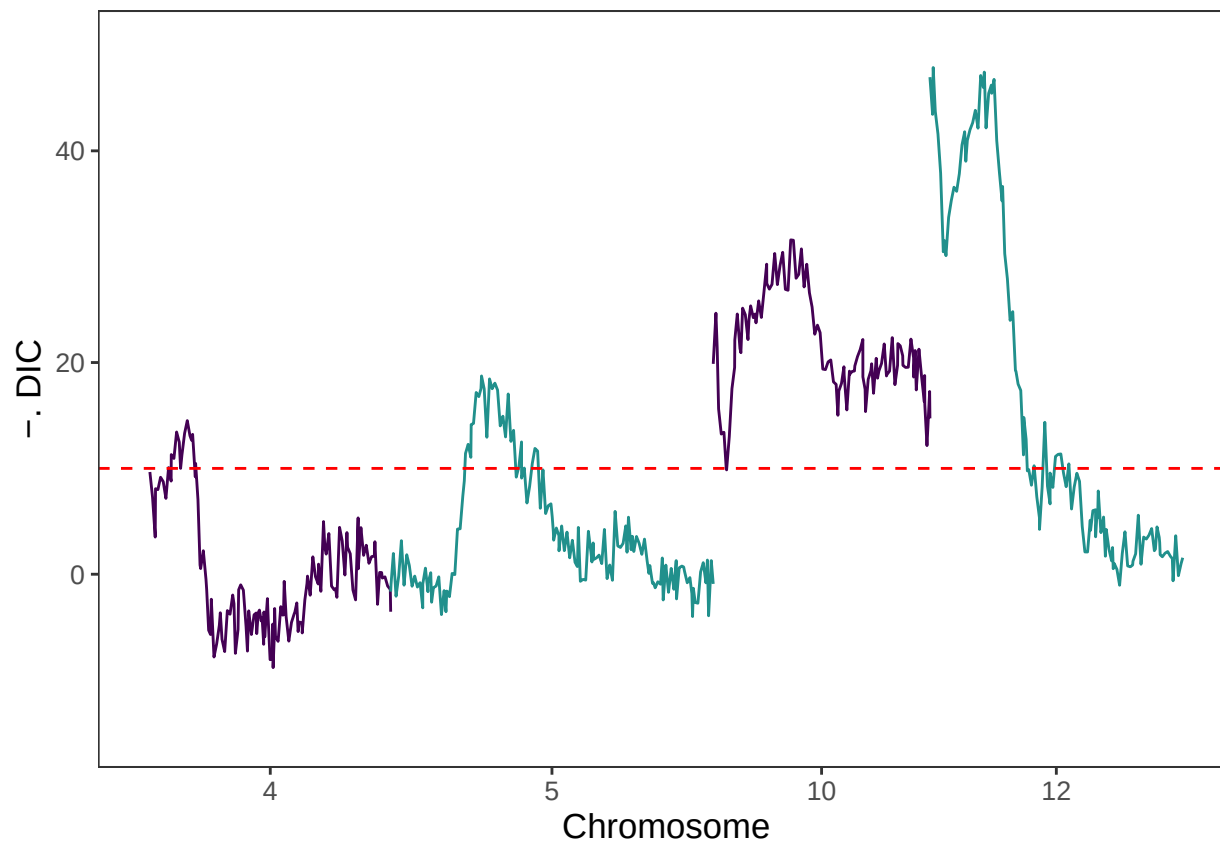
```

```

p3.A <- refine.1_summ$plot + geom_hline(yintercept=10,color="red",linetype=2) +
  ylim(-15,50)

p3.A

```



All the QTLs have a DIC greater than 10.

```
BayesCI(refine.1,data_cs,chrom="4",CI.prob=0.9)
BayesCI(refine.1,data_cs,chrom="5",CI.prob=0.9)
BayesCI(refine.1,data_cs,chrom="10",CI.prob=0.9)
BayesCI(refine.1,data_cs,chrom="12",CI.prob=0.9)
```

```
##          marker chrom cM          LL deltaDIC
## 4135   chr4.2.1      4  2 -2832.476 -3.511214
## 5151  chr4.77.12     4 77 -2832.859  2.424248
```

```
##          marker chrom  cM          LL deltaDIC
## 5712    C5_7_1       5 30.13 -2830.582 -14.14109
## 5898  chr5.45.12     5 45.00 -2831.080 -12.55242
```

```
##          marker chrom cM          LL deltaDIC
## 11781  chr10.17.1     10 17 -2831.657 -25.82547
## 12037  chr10.37.12    10 37 -2831.689 -25.24469
```

```
## Warning in max(which(tmp$cdf <= 0.5 - CI.prob/2)): no non-missing arguments to
## max; returning -Inf
```

```
##          marker chrom cM          LL deltaDIC
## 13653   C12_1_1      12  0 -2829.831 -46.96249
## 13976  chr12.25.12    12 25 -2832.470 -40.97583
```

```
##Discovery with digenic dominance model:
```

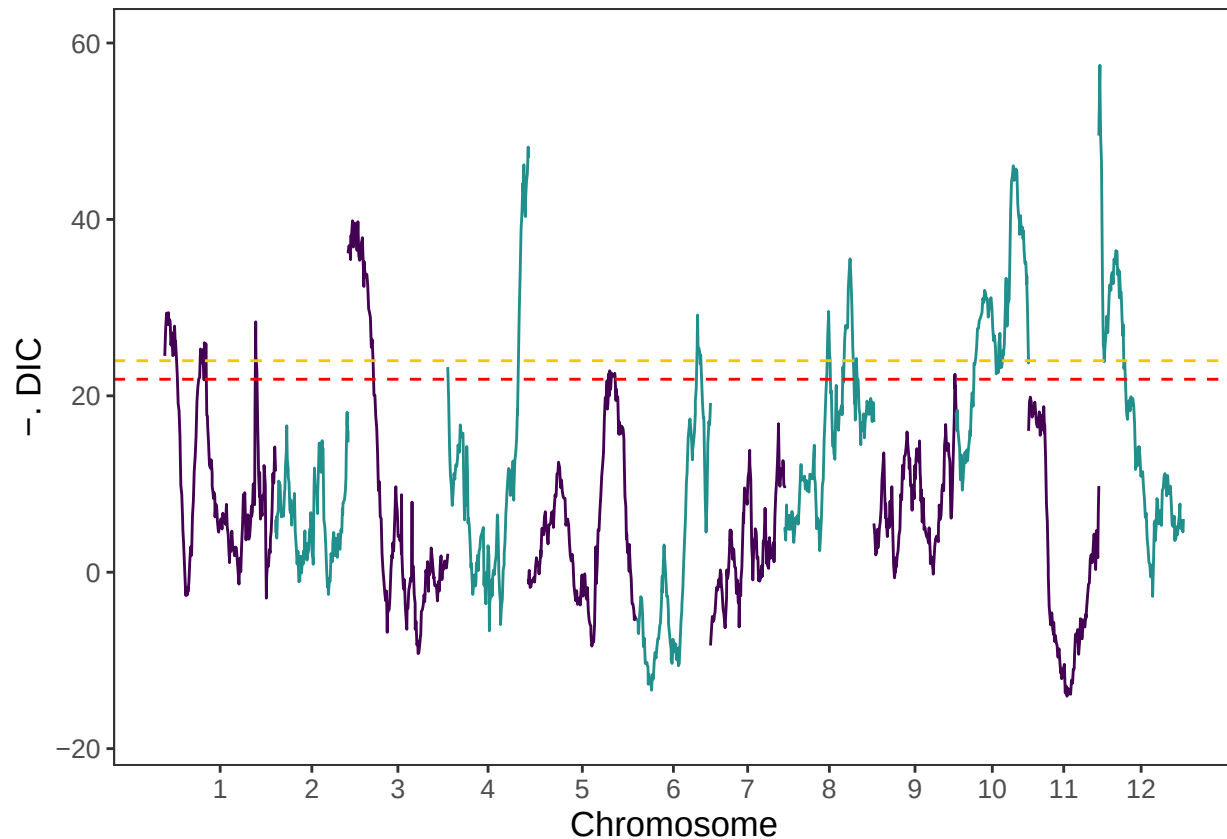
```
ans2 <- scan1(data = data_cs,  
              trait = "Common.scab",  
              params = list(burnIn=50,nIter=1000),  
              dominance = 2,  
              n.core = 6)
```

```
ans2.summary <- scan1_summary(ans2, position="cM")  
ans2.summary$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 39	chr1.4.1	1	4.00	-2861.642	-29.42765
## 2651	C2_30_2	2	79.98	-2864.234	-18.14026
## 2738	chr3.5.1	3	5.00	-2859.832	-39.84050
## 5309	chr4.90.1	4	90.00	-2850.714	-48.20512
## 6460	chr5.91.1	5	91.00	-2866.422	-22.83767
## 7758	C6_24_1	6	68.50	-2865.806	-29.16581
## 8957	chr7.76.1	7	76.00	-2870.460	-16.83504
## 10020	chr8.73.1	8	73.00	-2859.363	-35.53039
## 11548	C9_27_5	9	90.58	-2866.563	-22.44211
## 12375	chr10.64.1	10	64.00	-2855.314	-46.07603
## 12633	chr11.2.1	11	2.00	-2865.359	-19.85677
## 13669	C12_2_1	12	1.20	-2847.501	-57.47154

```
p1.B <- ans2.summary$plot +  
  geom_hline(yintercept=alpha.05_dom,color="gold2",linetype=2)+  
  geom_hline(yintercept=alpha.1_dom,color="red",linetype=2) + ylim(-18,60)
```

```
p1.B
```



```
##Composite interval mapping (CIM)
```

```
qtl.1at4 <- ans2.summary$peaks$marker[1]
qtl.3at5 <- ans2.summary$peaks$marker[3]
qtl.4at90 <- ans2.summary$peaks$marker[4]
qtl.6at68 <- ans2.summary$peaks$marker[6]
qtl.8at73 <- ans2.summary$peaks$marker[8]
qtl.10at64 <- ans2.summary$peaks$marker[10]
qtl.12at1 <- ans2.summary$peaks$marker[12]
```

```
covariate <- data.frame(marker = c(qtl.1at4,qtl.3at5,qtl.4at90,qtl.6at68,
                                   qtl.8at73,qtl.10at64,qtl.12at1),
                        dominance = 2, epistasis = FALSE)
```

```
chr <- data.frame(chr = c(1,3,4,6,8,10,12))
```

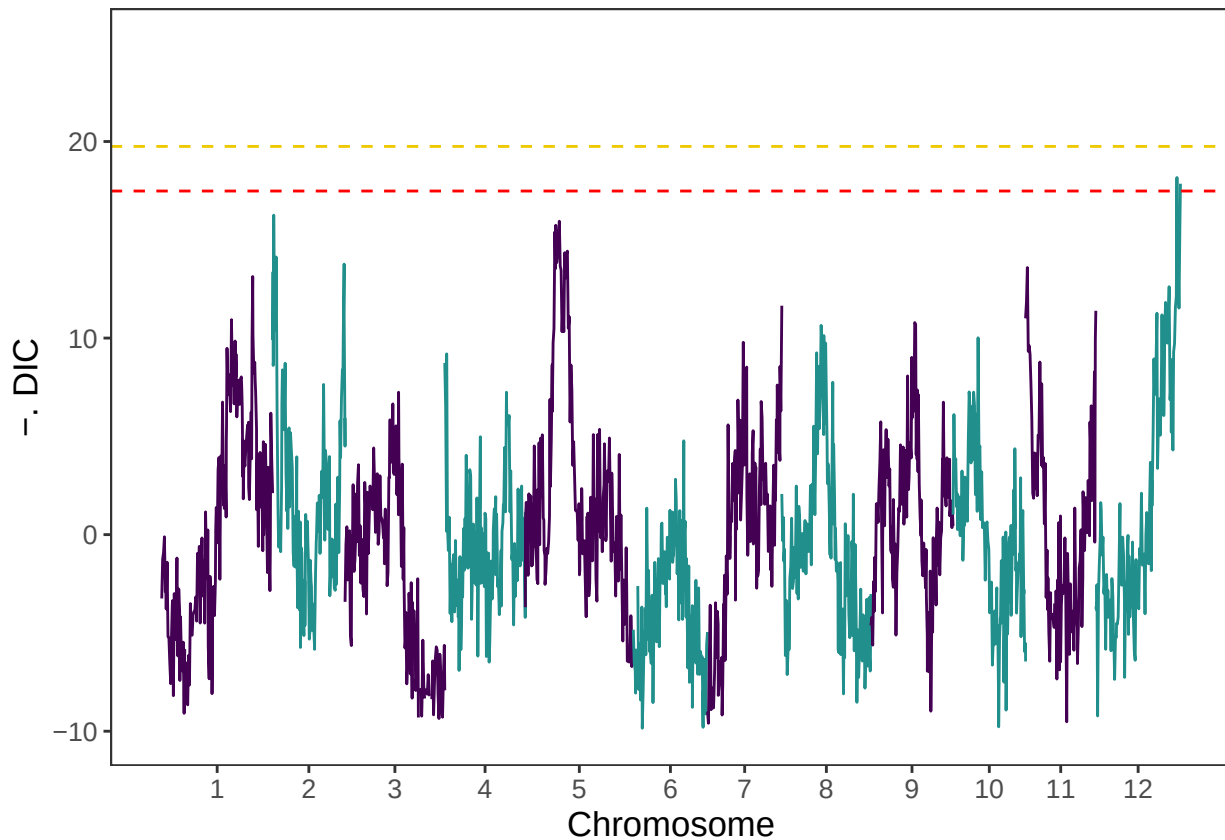
```
ans2_CIM <- scan1(data = data_cs,
                  trait = "Common.scab",
                  params = list(burnIn=50,nIter=1000),
                  covariate = covariate,
                  dominance = 2,
                  n.core = 4)
```

```
ans2_CIM.summ <- scan1_summary(ans2_CIM, position="cM")
ans2_CIM.summ$peaks
```

##	marker	chrom	cM	LL	deltaDIC
## 1288	C1_27_1	1	101.74	-2729.337	-13.127782
## 1621	C2_2_2	2	1.25	-2726.612	-16.251312
## 3443	C3_15_1	3	59.86	-2731.540	-7.242796
## 4147	C4_2_1	4	2.12	-2731.435	-9.196033
## 5803	chr5.38.1	5	38.00	-2726.592	-15.943792
## 7599	C6_20_1	6	56.44	-2735.782	-4.771812
## 9062	C7_30_1	7	83.07	-2731.864	-11.644823
## 9616	chr8.44.1	8	44.00	-2730.520	-10.644072
## 10999	chr9.49.1	9	49.00	-2729.651	-10.789635
## 11918	chr10.28.1	10	28.00	-2731.687	-10.013104
## 12633	chr11.2.1	11	2.00	-2728.272	-13.585897
## 14824	C12_22_1	12	90.73	-2725.911	-18.166451

```
p2.B <- ans2_CIM.summ$plot + geom_hline(yintercept=alpha.05_add,color="gold2",linetype=2) +
  geom_hline(yintercept=alpha.1_add,color="red",linetype=2) + ylim(-10,25)
```

p2.B



With CIM, we found no additional QTLs.

```
##QTL refinement
```

```
refine.2 <- NULL
ans2_refine <- vector("list", 7)
```

```

for(i in 1:7){
  ans2_refine[[i]] <- scan1(data = data_cs,
    trait = "Common.scab",
    params = list(burnIn=50,nIter=1000),
    covariate = covariate[-i,],
    chrom = chr[i,],
    dominance = 2,
    n.core = 4)
  refine.2 <- rbind(refine.2,ans2_refine[[i]])
}

```

```

refine.2_summ <- scan1_summary(refine.2, position="cM")

```

```

refine.2_summ$peaks

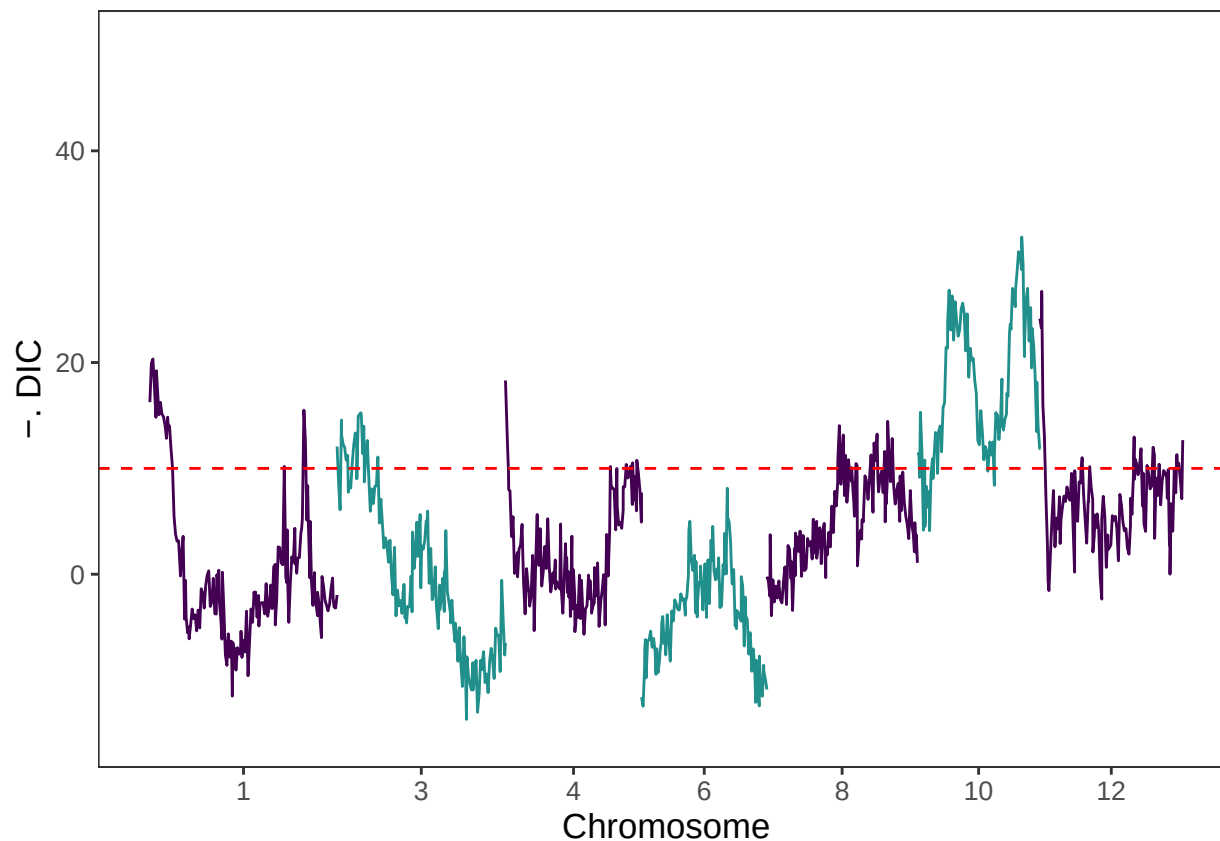
```

##	marker	chrom	cM	LL	deltaDIC
## 15	chr1.2.1	1	2.00	-2739.335	-20.335239
## 2881	C3_5_1	3	15.69	-2739.070	-15.251275
## 4119	C4_1_1	4	0.00	-2734.622	-18.305265
## 7603	C6_21_2	6	56.78	-2735.515	-8.115992
## 10116	chr8.80.1	8	80.00	-2740.287	-14.443906
## 12450	C10_16_1	10	69.10	-2737.940	-31.852759
## 13670	C12_2_2	12	1.23	-2739.854	-26.725160

```

p3.B <- refine.2_summ$plot + geom_hline(yintercept=10,color="red",linetype=2) +
  ylim(-15,50)
p3.B

```



For obvious double peaks on chromosomes 1 and 8 with DIC greater than 10, we considered these as separate QTLs.

```
refine.2$marker[(refine.2$chrom == 1) & (refine.2$deltaDIC <= -15)]
```

```
## [1] "C1_1_1"      "C1_1_2"      "chr1.1.1"    "chr1.1.2"    "chr1.1.3"
## [6] "chr1.1.4"    "chr1.1.5"    "chr1.1.6"    "chr1.1.7"    "chr1.1.8"
## [11] "chr1.1.9"    "chr1.1.10"   "chr1.1.11"   "chr1.1.12"   "chr1.2.1"
## [16] "chr1.2.2"    "chr1.2.3"    "chr1.2.4"    "chr1.2.5"    "chr1.2.6"
## [21] "chr1.2.7"    "chr1.2.8"    "chr1.2.9"    "chr1.2.10"   "chr1.2.11"
## [26] "chr1.2.12"   "chr1.3.1"    "chr1.3.2"    "chr1.3.3"    "chr1.3.4"
## [31] "chr1.3.5"    "chr1.3.6"    "chr1.3.7"    "chr1.3.8"    "chr1.3.9"
## [36] "chr1.3.10"   "chr1.3.11"   "chr1.3.12"   "C1_2_1"      "C1_2_2"
## [41] "C1_2_3"      "C1_2_4"      "C1_2_5"      "C1_2_6"      "chr1.5.1"
## [46] "chr1.5.2"    "chr1.5.3"    "chr1.5.4"    "chr1.5.5"    "chr1.5.6"
## [51] "chr1.5.7"    "chr1.5.8"    "chr1.5.9"    "chr1.5.10"   "chr1.5.11"
## [56] "chr1.5.12"   "chr1.6.1"    "chr1.6.2"    "chr1.6.3"    "chr1.6.4"
## [61] "chr1.6.5"    "chr1.6.6"    "chr1.6.7"    "chr1.6.8"    "chr1.6.9"
## [66] "chr1.6.10"   "chr1.6.11"   "chr1.6.12"   "chr1.7.1"    "chr1.7.2"
## [71] "chr1.7.3"    "chr1.7.4"    "chr1.7.5"    "chr1.7.6"    "chr1.7.7"
## [76] "chr1.7.8"    "chr1.7.9"    "chr1.7.10"   "chr1.7.11"   "chr1.7.12"
## [81] "chr1.8.1"    "chr1.8.2"    "chr1.8.3"    "chr1.8.4"    "chr1.8.5"
## [86] "chr1.8.6"    "chr1.8.7"    "chr1.8.8"    "chr1.8.9"    "chr1.8.10"
## [91] "chr1.8.11"   "chr1.8.12"   "chr1.102.1"  "chr1.102.2"  "chr1.102.3"
## [96] "chr1.102.4"  "chr1.102.5"  "chr1.102.6"  "chr1.102.7"  "chr1.102.8"
## [101] "chr1.102.9"  "chr1.102.10" "chr1.102.11" "chr1.102.12"
```

```
refine.2$marker[(refine.2$chrom == 8) & (refine.2$deltaDIC <= -14)]
```

```
## [1] "chr8.48.1" "chr8.48.2" "chr8.48.3" "chr8.48.4" "chr8.48.5"
## [6] "chr8.48.6" "chr8.48.7" "chr8.48.8" "chr8.48.9" "chr8.48.10"
## [11] "chr8.48.11" "chr8.48.12" "chr8.80.1" "chr8.80.2" "chr8.80.3"
## [16] "chr8.80.4" "chr8.80.5" "chr8.80.6" "chr8.80.7" "chr8.80.8"
## [21] "chr8.80.9" "chr8.80.10" "chr8.80.11" "chr8.80.12"
```

The 2nd QTL chromosome 1 is at 102 cM and the 2nd QTL on chromosome 8 is at 48 cM.

```
BayesCI(refine.2,data_cs,chrom="1",CI.prob=0.9)
BayesCI(refine.2,data_cs,chrom="3",CI.prob=0.9)
BayesCI(refine.2,data_cs,chrom="4",CI.prob=0.9)
BayesCI(refine.2,data_cs,chrom="8",CI.prob=0.9)
BayesCI(refine.2,data_cs,chrom="10",CI.prob=0.9)
BayesCI(refine.2,data_cs,chrom="12",CI.prob=0.9)
```

```
##          marker chrom cM          LL deltaDIC
## 1          C1_1_1      1  0 -2742.542 -16.25516
## 140 chr1.11.12        1 11 -2744.630 -12.84034
```

```
##          marker chrom cM          LL deltaDIC
## 2698 chr3.2.1         3  2 -2742.901 -6.094373
## 3019 chr3.26.12       3 26 -2743.571 -8.347348
```

```
## Warning in max(which(tmp$cdf <= 0.5 - CI.prob/2)): no non-missing arguments to
## max; returning -Inf
```

```
##          marker chrom  cM          LL deltaDIC
## 4119 C4_1_1          4 0.00 -2734.622 -18.305265
## 4150 C4_2_4          4 2.12 -2739.557  -7.995437
```

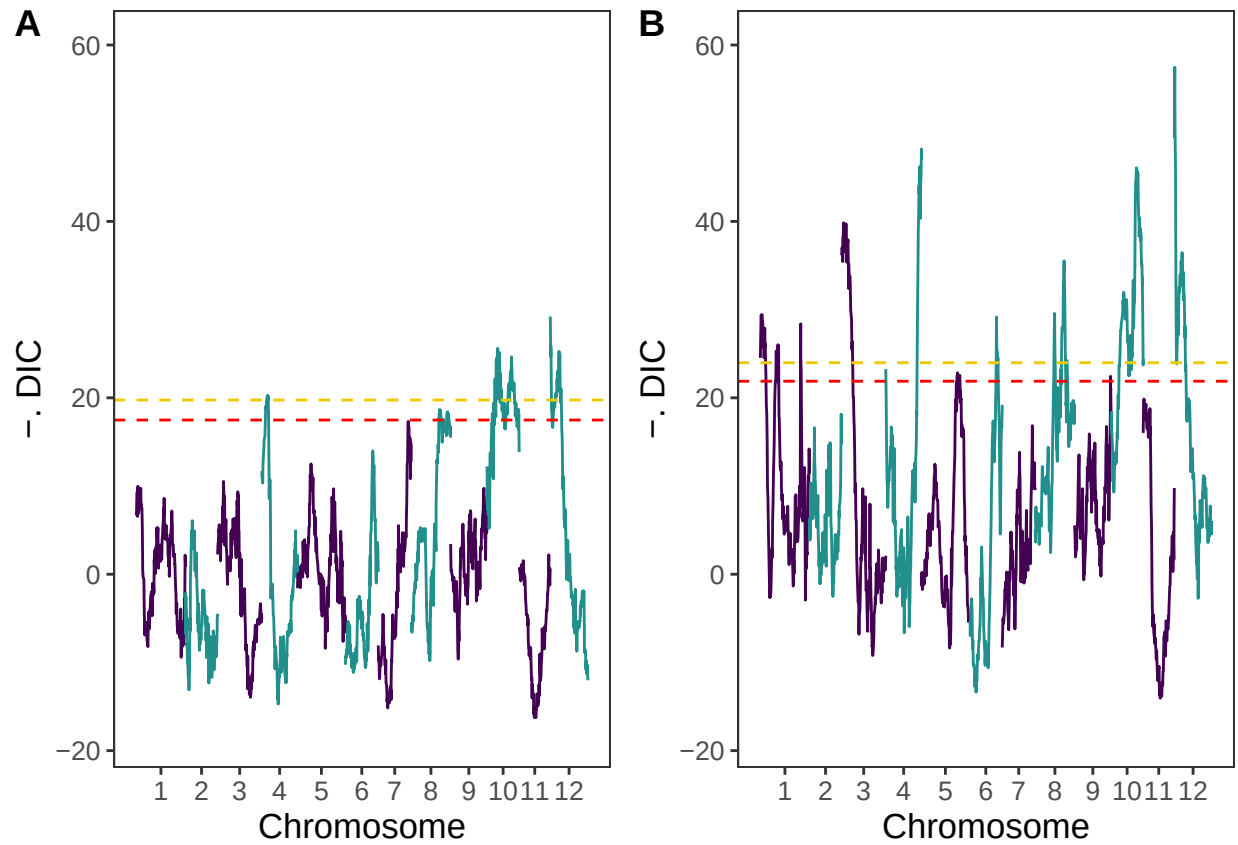
```
##          marker chrom cM          LL deltaDIC
## 9580 chr8.41.1        8 41 -2744.337  -3.952207
## 10163 chr8.83.12      8 83 -2742.587 -12.816573
```

```
##          marker chrom  cM          LL deltaDIC
## 11829 C10_6_1        10 20.04 -2742.495 -23.70747
## 12468 C10_17_3       10 70.92 -2744.300 -20.55799
```

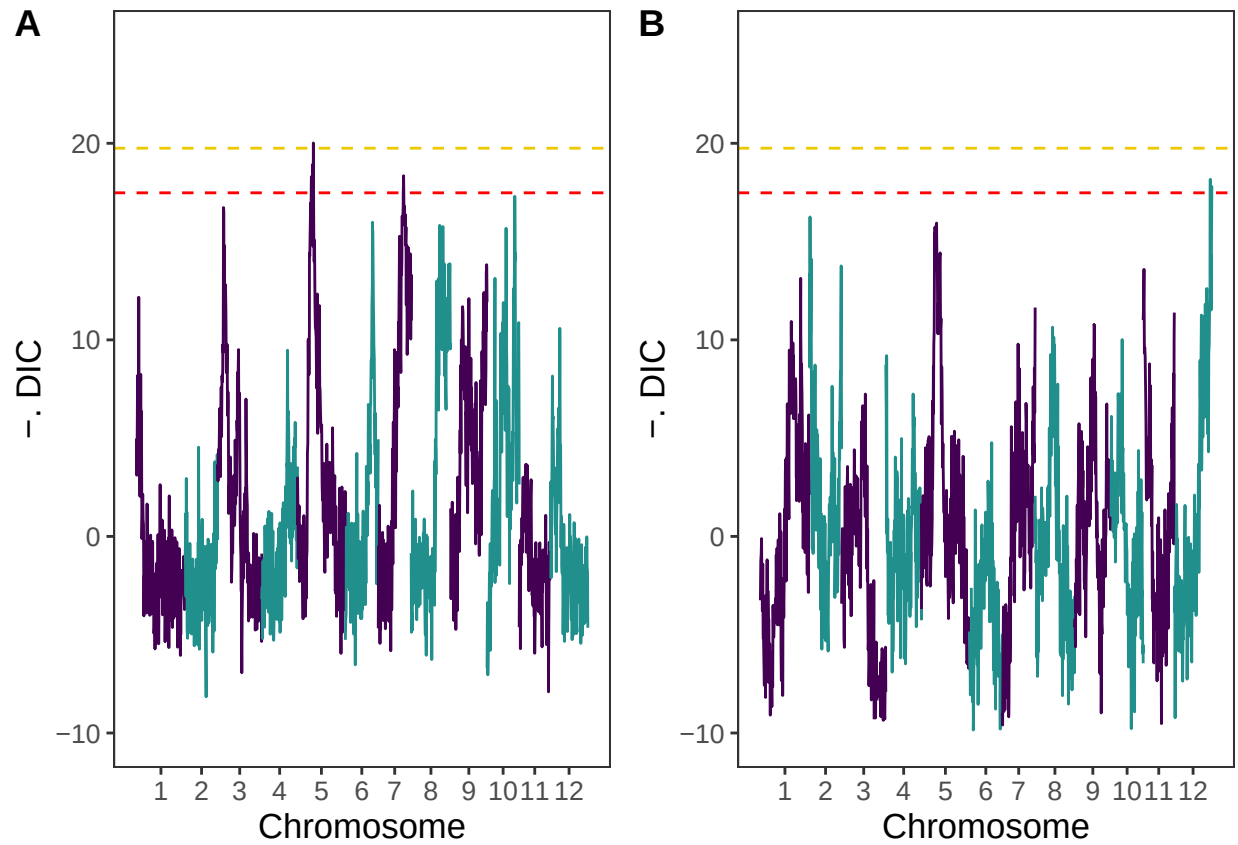
```
## Warning in max(which(tmp$cdf <= 0.5 - CI.prob/2)): no non-missing arguments to
## max; returning -Inf
```

```
##          marker chrom cM          LL deltaDIC
## 13653 C12_1_1        12  0 -2740.940 -24.15129
## 13696 chr12.3.12     12  3 -2746.102 -13.10263
```

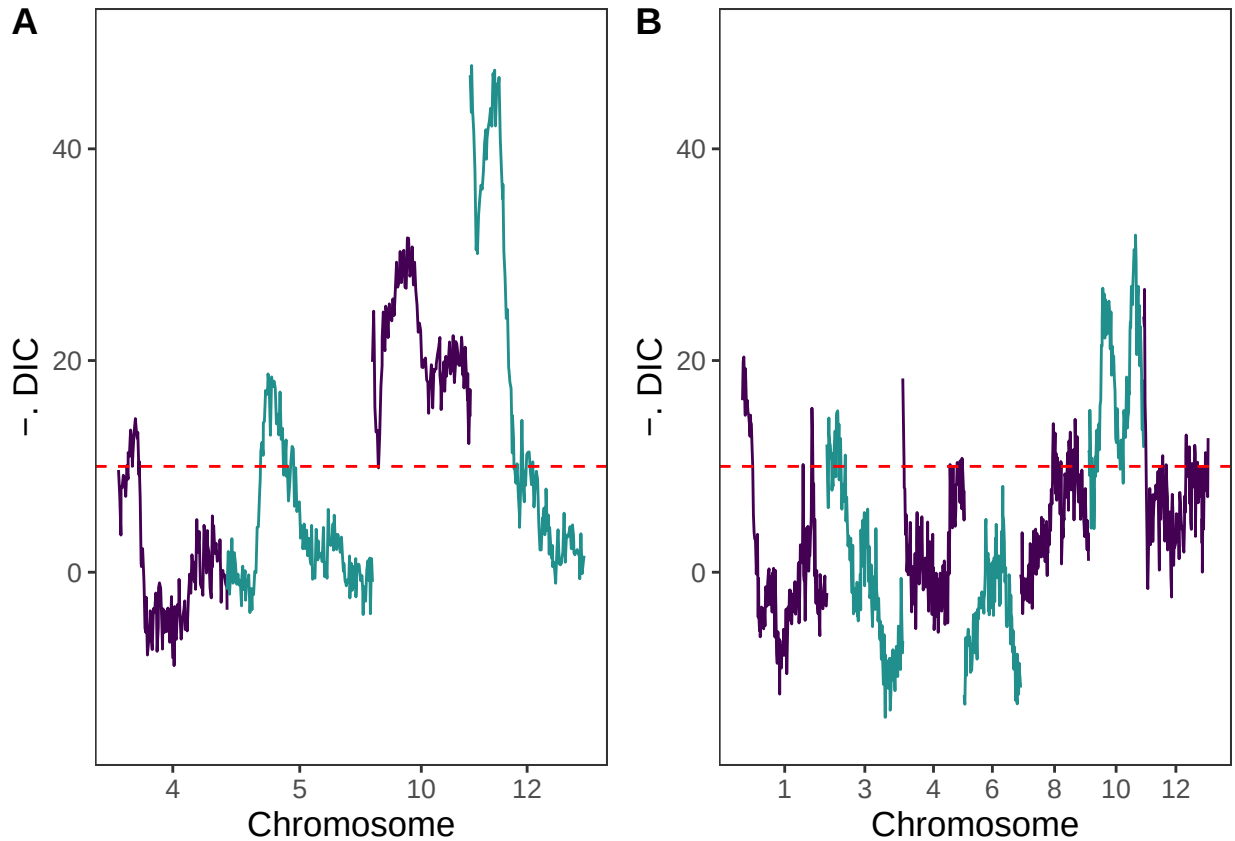
```
ggarrange(p1.A,p1.B,labels = c("A","B"))
```

```
ggsave("FigureS8.png",device="png",dpi=600,height=3.5,width=9)
ggarrange(p2.A,p2.B,labels = c("A","B"))
```



```
ggsave("FigureS9.png",device="png",dpi=600,height=3.5,width=9)
ggarrange(p3.A,p3.B,labels = c("A","B"))
```



```
ggsave("Figure3.png",device="png",dpi=600,height=3.5,width=9)
```

We discovered different peaks with additive and digenic dominance model. Now, we test different effect levels of the identified QTLs: dom= 2:4 for QTLs detected with additive model and dom=3:4 for QTLs detected with digenic dominance model. Complex models will consecutively be accepted if the DIC is lowered by at least 10 points compared to the previous model.

Additive QTLs and higher dominance

```
qtl.4at14 <- refine.1_summ$peaks$marker[1]
qtl.5at34 <- refine.1_summ$peaks$marker[2]
qtl.10at29 <- refine.1_summ$peaks$marker[3]
qtl.12at1.23 <- refine.1_summ$peaks$marker[4]

##The number in parenthesis is the position of the marker in the dataframe.

# QTL on chr04

fitqtl.4at14.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.4at14,dominance=2))
fitqtl.4at14.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.4at14,dominance=3))
fitqtl.4at14.3 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.4at14,dominance=4))
```

```
fitqtl.4at14.1$deltaDIC
```

```
## [1] -15.6431
```

```
fitqtl.4at14.2$deltaDIC
```

```
## [1] -20.07361
```

```
fitqtl.4at14.3$deltaDIC
```

```
## [1] -19.68942
```

As none of the higher dominance model had a DIC at least 10 points lower, we accept the QTL refinement model (dom = 1) for this QTL on chromosome 4 at 14 cM.

```
fitqtl.4at14 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,  
  qtl = data.frame(marker=qtl.4at14,dominance=1))
```

```
fitqtl.4at14$var
```

```
##               Mean CI.lower CI.upper  
## chr4.14.1 additive 0.03      0.01      0.04  
## residual          0.97      0.96      0.99
```

Additive effects of parental haplotypes in the single-QTL model.

```
fitqtl.4at14$plots$chr4.14.1$additive$data
```

```
##           parent x      mean  CI.lower  CI.upper  
## Desiree.1 Desiree 1 -0.04494117 -0.06357783 -0.02435426  
## Desiree.2 Desiree 2 -0.05921269 -0.15552367 -0.03151301  
## Desiree.3 Desiree 3 -0.04633011 -0.06528133 -0.02614337  
## Desiree.4 Desiree 4 -0.03483755 -0.06021688  0.05173963  
## Electra.1 Electra 1 -0.03471266 -0.06132612  0.05663823  
## Electra.2 Electra 2 -0.03673137 -0.06102054  0.03172336  
## Electra.3 Electra 3 -0.05036819 -0.07536390 -0.02748091  
## Electra.4 Electra 4  0.49576563  0.36741540  0.62491431  
## Picasso.1 Picasso 1 -0.04887690 -0.06957156 -0.02788013  
## Picasso.2 Picasso 2 -0.04594532 -0.06485117 -0.02599276  
## Picasso.3 Picasso 3 -0.04741098 -0.06659501 -0.02677188  
## Picasso.4 Picasso 4 -0.04639871 -0.06537828 -0.02616917
```

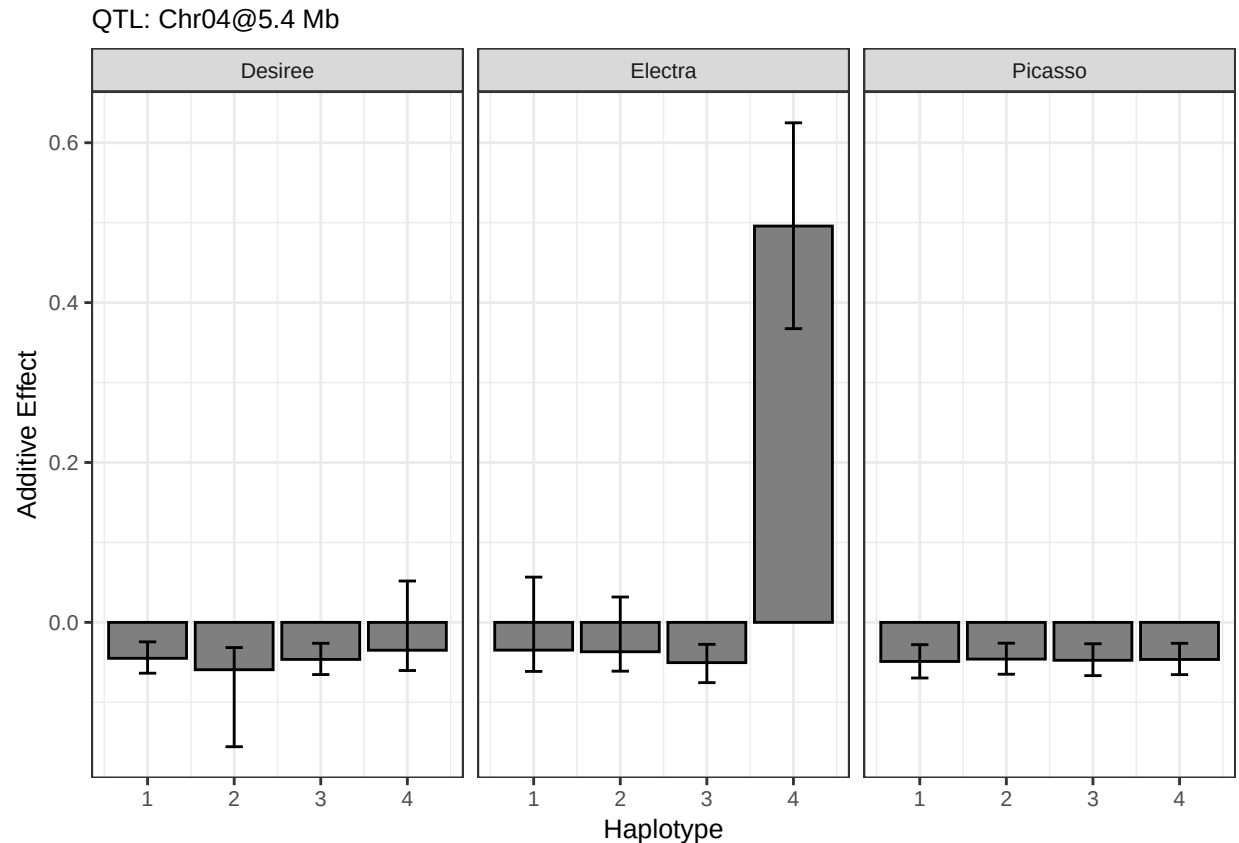
Additive effects of parental haplotypes are significantly different than 0 at alpha 0.1 at the QTL for all haplotypes except Desiree.4, Electra.1 and Electra.2.

```
p1_add <- fitqtl.4at14$plots$chr4.14.1$additive
```

```
p1_add$labels$subtitle <- "QTL: Chr04@5.4 Mb"
```

```
p1.add <- p1_add + theme(text = element_text(size = 10)) + labs(title = NULL)
```

```
p1.add
```



```
# QTL on chr05
```

```
fitqtl.5at34.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
  qtl = data.frame(marker=qtl.5at34,dominance=2))
fitqtl.5at34.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
  qtl = data.frame(marker=qtl.5at34,dominance=3))
fitqtl.5at34.3 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
  qtl = data.frame(marker=qtl.5at34,dominance=4))
```

```
fitqtl.5at34.1$deltaDIC
```

```
## [1] -11.58016
```

```
fitqtl.5at34.2$deltaDIC
```

```
## [1] -27.37247
```

```
fitqtl.5at34.3$deltaDIC
```

```
## [1] -27.30729
```

As none of the higher dominance model had a DIC at least 10 points lower, we accept the QTL refinement model (dom = 1) for this QTL on chromosome 5 at 34 cM.

```
fitqtl.5at34 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
  qtl = data.frame(marker=qtl.5at34,dominance=1))
```

```
fitqtl.5at34$var
```

```
##                Mean CI.lower CI.upper
## chr5.34.1 additive 0.03      0.02      0.04
## residual          0.97      0.96      0.98
```

```
### Additive effects of parental haplotypes in the single-QTL model.
```

```
fitqtl.5at34$plots$chr5.34.1$additive$data
```

```
##          parent x          mean    CI.lower    CI.upper
## Desiree.1 Desiree 1 -0.0266501981 -0.09045075  0.058898043
## Desiree.2 Desiree 2 -0.1608509565 -0.32034011 -0.022529825
## Desiree.3 Desiree 3 -0.0367448712 -0.10397600  0.029774243
## Desiree.4 Desiree 4  0.1433288015 -0.02266699  0.288729695
## Electra.1 Electra 1 -0.0330578495 -0.09448936  0.030412177
## Electra.2 Electra 2 -0.0272313185 -0.09117523  0.050984107
## Electra.3 Electra 3  0.2570505992  0.02575104  0.424709658
## Electra.4 Electra 4  0.0695392764 -0.05647804  0.273787026
## Picasso.1 Picasso 1 -0.0550113386 -0.16246556  0.007060944
## Picasso.2 Picasso 2 -0.0534633771 -0.15562837  0.007451288
## Picasso.3 Picasso 3  0.0002232959 -0.06686359  0.144581215
## Picasso.4 Picasso 4 -0.0771320634 -0.22149106 -0.002494419
```

Additive effects of parental haplotypes are significantly different than 0 at alpha 0.1 at the QTL for haplotypes Desiree.2, Electra.3 and Picasso.4.

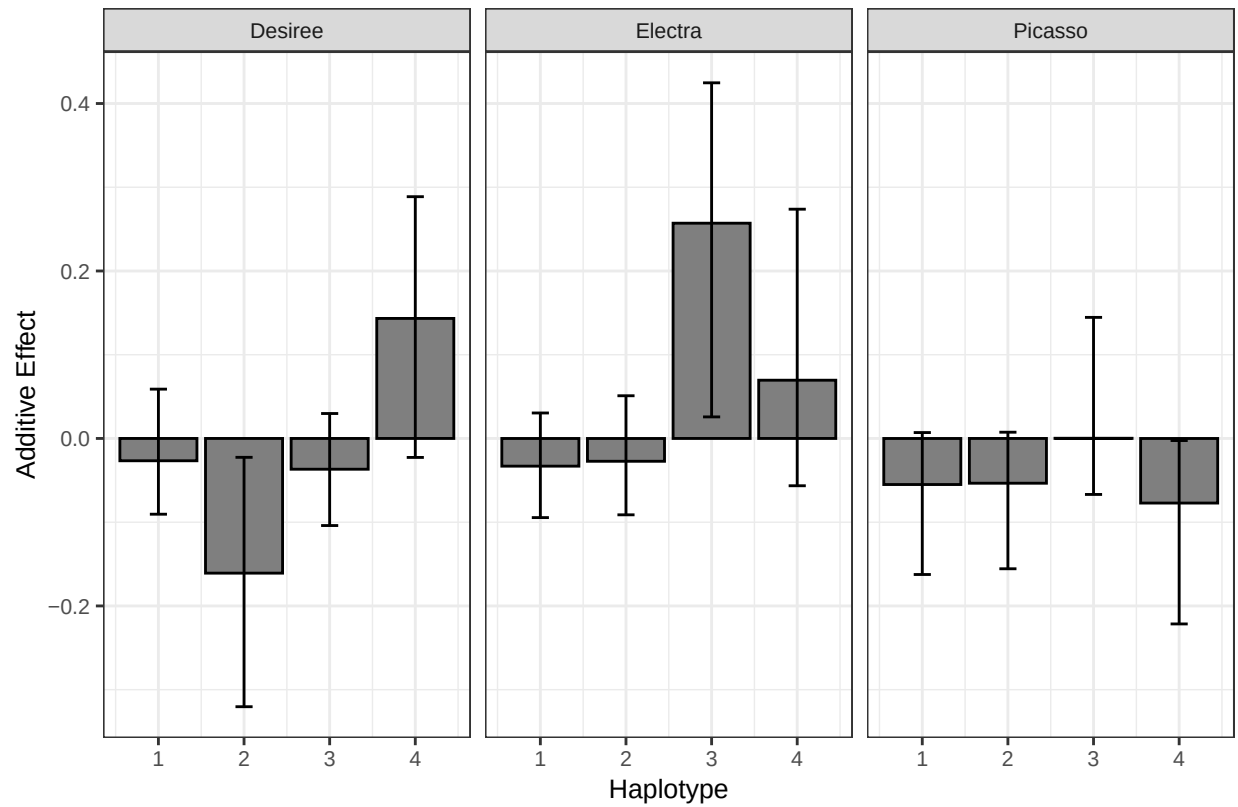
```
p2_add <- fitqtl.5at34$plots$chr5.34.1$additive
```

```
p2_add$labels$subtitle <-"QTL: Chr05@7.3 Mb"
```

```
p2.add <- p2_add + theme(text = element_text(size = 10)) + labs(title = NULL)
```

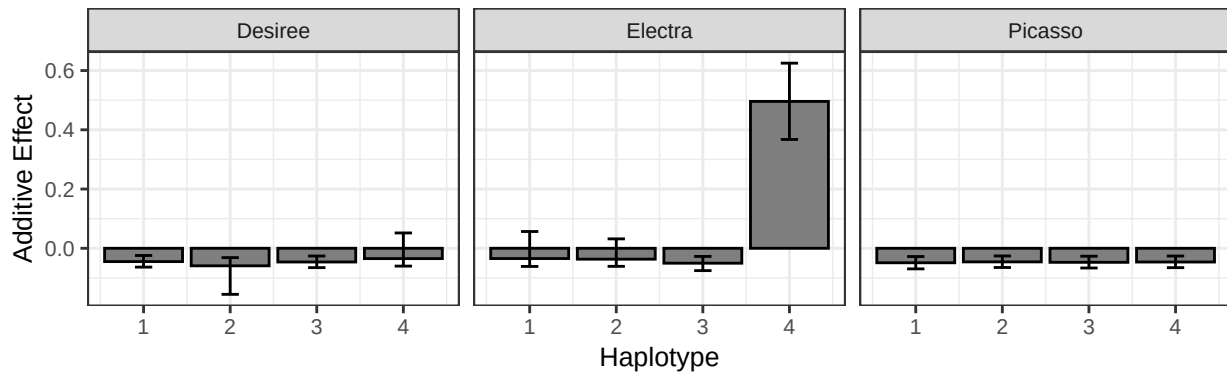
```
p2.add
```

QTL: Chr05@7.3 Mb

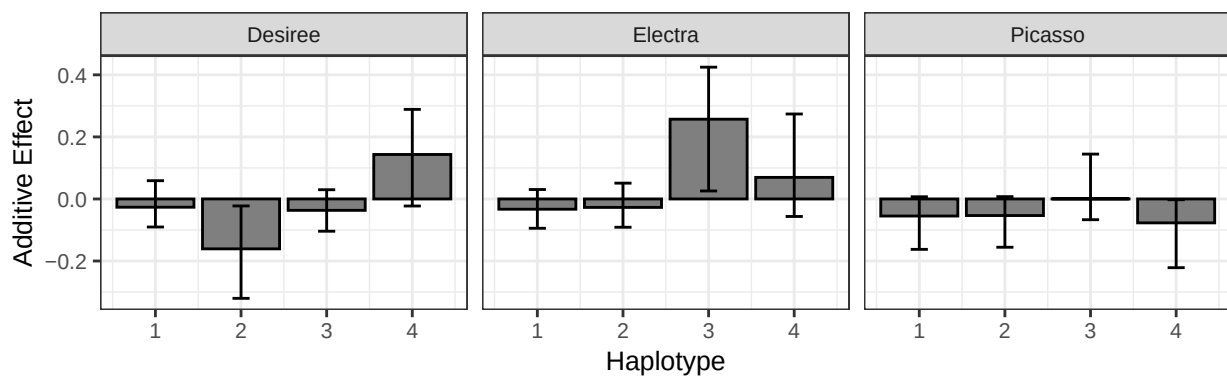


```
ggarrange(p1.add,p2.add, nrow = 2, labels = c("A","B"))
```

A QTL: Chr04@5.4 Mb



B QTL: Chr05@7.3 Mb



```
ggsave("FigureS12.png",device="png",dpi=600,height=5,width=4)
```

```
# QTL on chr10
```

```
fitqtl.10at29.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at29,dominance=2))
fitqtl.10at29.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at29,dominance=3))
fitqtl.10at29.3 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at29,dominance=4))
```

```
fitqtl.10at29.1$deltaDIC
```

```
## [1] -30.07913
```

```
fitqtl.10at29.2$deltaDIC
```

```
## [1] -38.54577
```

```
fitqtl.10at29.3$deltaDIC
```

```
## [1] -50.01875
```


Even if the DIC of the dom=2 and dom=3 models has not lowered at least 10 point, the more complex model has lowered the DIC by at least 10 points compared to QTL refinement model. Hence, we accept the quadrigenic dominance model (dom = 4) for this QTL on chromosome 10 at 29 cM.

```
fitqtl.10at29.3$var
```

```
##                               Mean CI.lower CI.upper
## chr10.29.1 additive         0.02      0.00      0.07
## chr10.29.1 digenic          0.03      0.01      0.07
## chr10.29.1 trigenic         0.04      0.01      0.07
## chr10.29.1 quadrigenic      0.04      0.02      0.07
## residual                    0.87      0.80      0.92
```

Additive and digenic effects of parental haplotypes in the single-QTL model.

```
fitqtl.10at29.3$plots$chr10.29.1$additive$data
```

```
##          parent x          mean    CI.lower    CI.upper
## Desiree.1 Desiree 1 -0.0020144943 -0.15297192 0.15530616
## Desiree.2 Desiree 2  0.0049394332 -0.09972195 0.12761772
## Desiree.3 Desiree 3 -0.0540719963 -0.34069708 0.07070906
## Desiree.4 Desiree 4  0.0081445428 -0.14392737 0.22859833
## Electra.1 Electra 1 -0.0007851100 -0.18726686 0.20356213
## Electra.2 Electra 2 -0.0433892707 -0.35951014 0.10177472
## Electra.3 Electra 3  0.1625884761 -0.04099884 0.64016666
## Electra.4 Electra 4  0.0418086144 -0.08518256 0.32705906
## Picasso.1 Picasso 1 -0.0405122873 -0.34320686 0.10385760
## Picasso.2 Picasso 2 -0.0029776426 -0.18030947 0.15109667
## Picasso.3 Picasso 3 -0.0744619736 -0.42020660 0.07371603
## Picasso.4 Picasso 4  0.0007317084 -0.12044518 0.12517931
```

```
fitqtl.10at29.3$effects$digenic
```

```
## , , Mean
```

```
##
##          Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr10.29.1          -0.01040043          -0.02119726          0.01850448
##          Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr10.29.1          -0.01445594          0.009568076          -0.0003696383
##          Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr10.29.1          -0.02583492          0.03789508          0.0261075
##          Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr10.29.1          0.007588797          -0.005880496          0.03466479
##          Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr10.29.1          -0.01114211          -0.06300988          -0.001028923
##          Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr10.29.1          0.01033733          -0.01008156          0.0171998
##          Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr10.29.1          0.02100938          -0.03385424          -0.04490271
##          Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr10.29.1          -0.0002158449          -0.004490677          0.01173256
##          Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr10.29.1          0.0008571988          -0.01842627          -0.01803941
```

```

##          Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr10.29.1          0.01174993          -0.01131642          -0.05861537
##          Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr10.29.1          0.05834616          0.00833808          -0.03327041
##          Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr10.29.1          0.001035508          0.0025012          0.05728481
##          Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr10.29.1          -0.164476          0.02279314          -0.03544649
##          Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr10.29.1          -0.03014748          -0.0002707384          0.01693435
##          Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr10.29.1          -0.03127118          0.0638675          0.0869799
##          Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr10.29.1          0.0573279          0.01361475          -0.01307309
##          Desiree.3+Electra.4 Desiree.4+Electra.4
## chr10.29.1          0.02996955          0.05265079
##
## , , Lower.CI
##
##          Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr10.29.1          -0.2120472          -0.2461145          -0.05852678
##          Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr10.29.1          -0.214255          -0.1086937          -0.1535234
##          Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr10.29.1          -0.3191196          -0.1115977          -0.1345477
##          Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr10.29.1          -0.1901387          -0.2472701          -0.1105551
##          Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr10.29.1          -0.239841          -0.4452847          -0.2054075
##          Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr10.29.1          -0.1480483          -0.2213565          -0.1557171
##          Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr10.29.1          -0.06135304          -0.3071909          -0.3588424
##          Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr10.29.1          -0.1414349          -0.1815521          -0.124825
##          Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr10.29.1          -0.1591986          -0.2483165          -0.2340893
##          Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr10.29.1          -0.1356787          -0.2406007          -0.3905298
##          Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr10.29.1          -0.03898828          -0.08921638          -0.3099385
##          Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr10.29.1          -0.1300576          -0.1528684          -0.04219503
##          Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr10.29.1          -0.6342369          -0.06082548          -0.3224899
##          Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr10.29.1          -0.3006686          -0.1784912          -0.1093862
##          Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr10.29.1          -0.3151125          -0.05115658          -0.03724664
##          Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr10.29.1          -0.05048817          -0.1052032          -0.2364591
##          Desiree.3+Electra.4 Desiree.4+Electra.4
## chr10.29.1          -0.07129322          -0.03874377
##

```

```
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr10.29.1      0.1286845      0.06119863      0.2053554
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr10.29.1      0.08173721      0.1904526      0.145295
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr10.29.1      0.1225391      0.3666667      0.3135165
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr10.29.1      0.2410189      0.1956056      0.3428424
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr10.29.1      0.1398892      0.04858863      0.1800493
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr10.29.1      0.2220655      0.1383338      0.2619187
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr10.29.1      0.229259      0.04447942      0.04694482
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr10.29.1      0.1204319      0.1215657      0.2021063
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr10.29.1      0.1648382      0.0811356      0.07368091
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr10.29.1      0.2109453      0.1425068      0.0405555
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr10.29.1      0.3936342      0.1609811      0.04715784
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr10.29.1      0.1270019      0.1703765      0.4058374
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr10.29.1      0.02532539      0.2443059      0.06526737
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr10.29.1      0.07399568      0.1589403      0.2441259
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr10.29.1      0.06677737      0.4217526      0.4970778
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr10.29.1      0.3950787      0.2091804      0.1212286
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr10.29.1      0.2986738      0.3603684
```

No additive effect or digenic effect of any single parental haplotpe or diplotype at this QTL is significantly different than zero at alpha 0.1.

```
# QTL on chr12

fitqtl.12at1.23.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                           qtl = data.frame(marker=qtl.12at1.23,dominance=2))
fitqtl.12at1.23.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                           qtl = data.frame(marker=qtl.12at1.23,dominance=3))
fitqtl.12at1.23.3 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                           qtl = data.frame(marker=qtl.12at1.23,dominance=4))
```

```
fitqtl.12at1.23.1$deltaDIC
```

```
## [1] -57.22085
```

```
fitqtl.12at1.23.2$deltaDIC
```

```
## [1] -65.04171
```

```
fitqtl.12at1.23.3$deltaDIC
```

```
## [1] -64.74348
```

Even if the DIC of the dom=2 model has not lowered at least 10 point, the more complex model (dom=3) has lowered the DIC by at least 10 points compared to the QTL refinement model. Hence, we accept the trigenic dominance model (dom = 3) for this QTL on chromosome 12 at 1.23 cM.

```
fitqtl.12at1.23.2$var
```

```
##               Mean CI.lower CI.upper
## C12_2_2 additive 0.03      0.00      0.10
## C12_2_2 digenic  0.04      0.01      0.08
## C12_2_2 trigenic 0.05      0.03      0.09
## residual         0.87      0.79      0.92
```

```
### Additive and digenic effects of parental haplotypes in the single-QTL model.
```

```
fitqtl.12at1.23.2$plots$C12_2_2$additive$data
```

```
##           parent x           mean    CI.lower    CI.upper
## Desiree.1 Desiree 1  0.018594020 -0.10180434  0.16295639
## Desiree.2 Desiree 2 -0.016118674 -0.22004061  0.09917357
## Desiree.3 Desiree 3  0.054369405 -0.07870248  0.32269689
## Desiree.4 Desiree 4 -0.005179180 -0.18982619  0.12152773
## Electra.1 Electra 1  0.111791357 -0.03737038  0.46594965
## Electra.2 Electra 2  0.001806616 -0.13498648  0.12475568
## Electra.3 Electra 3  0.042975885 -0.06817969  0.26279868
## Electra.4 Electra 4  0.026486725 -0.11070551  0.22567383
## Picasso.1 Picasso 1 -0.054914570 -0.38844216  0.10143984
## Picasso.2 Picasso 2 -0.224743490 -0.69032401  0.03368564
## Picasso.3 Picasso 3  0.065810200 -0.07594784  0.41346349
## Picasso.4 Picasso 4 -0.020878295 -0.27789103  0.11316242
```

```
fitqtl.12at1.23.2$effects$digenic
```

```
## , , Mean
```

```
##
```

```
##           Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C12_2_2           -0.008280157           -0.00574355           0.06728699
##           Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C12_2_2           0.02136976           0.004398771           0.0004283689
##           Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C12_2_2           0.04997905           0.01709696           -0.002796773
##           Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C12_2_2           0.08266067           0.0125246           0.02138893
##           Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
```

## C12_2_2	0.004633983	0.01236638	0.01004992
## Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4	
## C12_2_2	-0.001832379	0.009680067	0.02986371
## Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1	
## C12_2_2	-0.002358668	-0.1397555	-0.0007731982
## Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2	
## C12_2_2	0.01967935	-0.1938812	0.01118285
## Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3	
## C12_2_2	0.01195067	-0.05028416	0.2631534
## Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3	
## C12_2_2	-0.02352389	0.01571325	0.006550708
## Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4	
## C12_2_2	-0.009011703	-0.007290536	-0.0003318902
## Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1	
## C12_2_2	-0.005859562	0.0472671	0.009848765
## Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2	
## C12_2_2	0.03442547	0.01598299	-0.003419478
## Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2	
## C12_2_2	-0.001766868	-0.0418955	0.02700536
## Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3	
## C12_2_2	-0.00910634	0.01524002	0.065862
## Desiree.4+Electra.3	Desiree.1+Electra.4	Desiree.2+Electra.4	
## C12_2_2	0.01894552	0.003043225	0.04271027
## Desiree.3+Electra.4	Desiree.4+Electra.4		
## C12_2_2	0.08804433	-0.05203124	
##			
## , , Lower.CI			
##			
## Desiree.1+Desiree.2	Desiree.1+Desiree.3	Desiree.1+Desiree.4	
## C12_2_2	-0.1862002	-0.1967168	-0.03148086
## Desiree.2+Desiree.3	Desiree.2+Desiree.4	Desiree.3+Desiree.4	
## C12_2_2	-0.06356773	-0.1451631	-0.176031
## Electra.1+Electra.2	Electra.1+Electra.3	Electra.1+Electra.4	
## C12_2_2	-0.04936828	-0.1172557	-0.2553319
## Electra.2+Electra.3	Electra.2+Electra.4	Electra.3+Electra.4	
## C12_2_2	-0.03632279	-0.1377937	-0.1127283
## Picasso.1+Picasso.2	Picasso.1+Picasso.3	Picasso.1+Picasso.4	
## C12_2_2	-0.1909512	-0.1347014	-0.1398343
## Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4	
## C12_2_2	-0.2245381	-0.1821431	-0.1787018
## Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1	
## C12_2_2	-0.187097	-0.5390071	-0.1861403
## Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2	
## C12_2_2	-0.06911936	-0.6647011	-0.1089963
## Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3	
## C12_2_2	-0.1651016	-0.3812966	-0.01755147
## Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3	
## C12_2_2	-0.2616539	-0.08107595	-0.1291961
## Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4	
## C12_2_2	-0.1695924	-0.1832819	-0.1660229
## Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1	
## C12_2_2	-0.1753328	-0.03735882	-0.08963956
## Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2	
## C12_2_2	-0.05164091	-0.09176195	-0.1712208

```

##          Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C12_2_2      -0.1786533      -0.3825027      -0.04277297
##          Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C12_2_2      -0.1782756      -0.06073827     -0.03906922
##          Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C12_2_2      -0.04350396     -0.1073987     -0.05211157
##          Desiree.3+Electra.4 Desiree.4+Electra.4
## C12_2_2      -0.03203002     -0.3691226
##
## , , Upper.CI
##
##          Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C12_2_2      0.07133395      0.1175535      0.4044178
##          Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C12_2_2      0.2365043      0.1412226      0.1536603
##          Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C12_2_2      0.3814762      0.2538426      0.1999888
##          Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C12_2_2      0.5031426      0.2170325      0.2765225
##          Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C12_2_2      0.2148148      0.2342979      0.1985785
##          Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C12_2_2      0.176529      0.2111497      0.3875616
##          Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C12_2_2      0.1382228      0.03148399     0.1367651
##          Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C12_2_2      0.2235455      0.03281026     0.1854285
##          Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C12_2_2      0.236858      0.05109503     0.6988191
##          Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C12_2_2      0.05367363      0.1988595      0.1580636
##          Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C12_2_2      0.06065008      0.07085761     0.1354813
##          Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C12_2_2      0.07783263      0.3332528      0.1597391
##          Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C12_2_2      0.3092157      0.2000286      0.1119974
##          Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C12_2_2      0.1229701      0.06530644     0.243619
##          Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C12_2_2      0.06630376      0.1866276      0.4334587
##          Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C12_2_2      0.1917442      0.1100705      0.3573485
##          Desiree.3+Electra.4 Desiree.4+Electra.4
## C12_2_2      0.4859083      0.04121761

```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

Digenic dominance QTLs and higher dominance

```

qtl.1at2 <- refine.2_summ$peaks$marker[1]
qtl.3at15 <- refine.2_summ$peaks$marker[2]
qtl.4at0 <- refine.2_summ$peaks$marker[3]
qtl.8at80 <- refine.2_summ$peaks$marker[5]
qtl.10at69 <- refine.2_summ$peaks$marker[6]
qtl.1at102 <- "chr1.102.1"
qtl.8at48 <- "chr8.48.1"

##The number in parenthesis is the position of the marker in the dataframe.

# QTL on chr01

fitqtl.1at2.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                      qtl = data.frame(marker=qtl.1at2,dominance=3))
fitqtl.1at2.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                      qtl = data.frame(marker=qtl.1at2,dominance=4))

```

```
fitqtl.1at2.1$deltaDIC
```

```
## [1] -40.01757
```

```
fitqtl.1at2.2$deltaDIC
```

```
## [1] -52.47621
```

We accept the quadrigenic dominance model for the QTL on chromosome 1 at 2 cM.

```
fitqtl.1at2.2$var
```

```
##
## chr1.2.1 additive      0.02      0.00      0.05
## chr1.2.1 digenic       0.03      0.01      0.06
## chr1.2.1 trigenic      0.04      0.01      0.07
## chr1.2.1 quadrigenic   0.05      0.02      0.08
## residual               0.87      0.81      0.92
```

```
### Additive and digenic effects of parental haplotypes in the single-QTL model.
fitqtl.1at2.2$plots$chr1.2.1$additive$data
```

```
##
## parent x      mean    CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.045855163 -0.29883597 0.06351259
## Desiree.2 Desiree 2  0.026198550 -0.07344449 0.25957947
## Desiree.3 Desiree 3  0.038072340 -0.07228585 0.32215994
## Desiree.4 Desiree 4 -0.003912166 -0.11909146 0.12777717
## Electra.1 Electra 1  0.044232623 -0.07343048 0.34765590
## Electra.2 Electra 2  0.018170605 -0.10167513 0.25627637
## Electra.3 Electra 3  0.040880234 -0.08127338 0.35791047
## Electra.4 Electra 4  0.002924022 -0.11691236 0.17344743
## Picasso.1 Picasso 1 -0.008428538 -0.13203822 0.11613509
## Picasso.2 Picasso 2 -0.031844768 -0.23088582 0.05332232
## Picasso.3 Picasso 3 -0.016075779 -0.18503832 0.10358739
## Picasso.4 Picasso 4 -0.064361960 -0.34558018 0.03782698
```

```
fitqtl.1at2.2$effects$digenic
```

```
## , , Mean
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.2.1      -0.10067      0.008199581      -0.03625399
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.2.1      0.02190358      0.04566036      -0.002551412
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.2.1      0.04174176      0.004349356      -0.06317396
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.2.1      -0.04071785      0.01549544      0.06829813
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.2.1      -0.01899188      -0.0353991      0.01823186
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.2.1      -0.03656141      0.001768793      -0.04361446
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.2.1      -0.003164811      -0.03019773      0.02945753
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.2.1      -0.001719671      0.002220609      -0.01824731
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.2.1      -0.0001062154      -0.06671741      -0.03281201
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.2.1      -0.002735594      0.01408093      0.001067578
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.2.1      -0.03743075      0.01338433      -0.03374108
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.2.1      -0.02144006      0.02759566      -0.00479392
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.2.1      0.001117339      0.009064431      -0.02397519
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.2.1      0.04704524      -0.008433331      0.03453455
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr1.2.1      -0.007710688      0.01589617      0.04397884
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.2.1      0.01801962      -0.01711106      0.01742795
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.2.1      -0.004111014      0.01578501
##
## , , Lower.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.2.1      -0.4731278      -0.07497139      -0.3005514
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.2.1      -0.06236758      -0.04173301      -0.1445899
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.2.1      -0.058296      -0.191409      -0.4395033
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.2.1      -0.3413944      -0.1192885      -0.05667548
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.2.1      -0.2278596      -0.308225      -0.09761966
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.2.1      -0.3104249      -0.1434367      -0.3416276
```



```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.2.1      -0.157415      -0.2607526      -0.04507512
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.2.1      -0.1176581      -0.092246      -0.1924977
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.2.1      -0.1215089      -0.3796847      -0.2698317
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.2.1      -0.1390116      -0.06074753      -0.1149446
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.2.1      -0.2848974      -0.06867722      -0.2682992
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.2.1      -0.2131677      -0.05180243      -0.1525884
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.2.1      -0.1245722      -0.1150828      -0.2340201
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.2.1      -0.03825007      -0.1437997      -0.05571836
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr1.2.1      -0.1623568      -0.08486401      -0.05066868
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.2.1      -0.1084365      -0.2185238      -0.1145032
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.2.1      -0.1415623      -0.08344509
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.2.1      0.02403566      0.177481      0.04341648
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.2.1      0.2617347      0.3487896      0.1337682
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.2.1      0.3611193      0.2380364      0.04230295
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.2.1      0.05913684      0.2554838      0.483719
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.2.1      0.07964964      0.04468438      0.2559157
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.2.1      0.04338974      0.1790659      0.0464969
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.2.1      0.140982      0.0421147      0.2779749
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.2.1      0.1215518      0.1365405      0.04825002
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.2.1      0.1355769      0.02550522      0.03584842
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.2.1      0.1311354      0.2041655      0.1447019
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.2.1      0.03330225      0.2109574      0.03707221
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.2.1      0.04381311      0.2797125      0.1461419
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.2.1      0.1632595      0.2133783      0.04812063
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.2.1      0.3397876      0.08422878      0.312124
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```

```
## chr1.2.1      0.1214365      0.2430029      0.3648762
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.2.1      0.2714739      0.0871119      0.2780651
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.2.1      0.1289654      0.2398558
```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

2nd QTL on chr01

```
fitqtl.1at102.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                          qtl = data.frame(marker=qtl.1at102,dominance=3))
fitqtl.1at102.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                          qtl = data.frame(marker=qtl.1at102,dominance=4))
```

```
fitqtl.1at102.1$deltaDIC
```

```
## [1] -39.01697
```

```
fitqtl.1at102.2$deltaDIC
```

```
## [1] -42.53184
```

We accept the trigenic dominance model for the QTL on chromosome 1 at 102 cM.

```
fitqtl.1at102.1$var
```

```
##      Mean CI.lower CI.upper
## chr1.102.1 additive 0.01      0.00      0.05
## chr1.102.1 digenic  0.03      0.01      0.07
## chr1.102.1 trigenic 0.06      0.03      0.09
## residual           0.90      0.84      0.94
```

Additive and digenic effects of parental haplotypes in the single-QTL model.

```
fitqtl.1at102.1$plots$chr1.102.1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1  0.0117913697 -0.07008298 0.15780060
## Desiree.2 Desiree 2 -0.0024193185 -0.08229872 0.06899957
## Desiree.3 Desiree 3 -0.0158088752 -0.14335570 0.05474976
## Desiree.4 Desiree 4  0.0007508213 -0.08434464 0.08636069
## Electra.1 Electra 1  0.0363484418 -0.05357524 0.27136684
## Electra.2 Electra 2  0.0258857736 -0.05904131 0.22924066
## Electra.3 Electra 3  0.0608171471 -0.06435577 0.43840024
## Electra.4 Electra 4 -0.0173433329 -0.16695594 0.05724459
## Picasso.1 Picasso 1 -0.0285233465 -0.21889509 0.04815342
## Picasso.2 Picasso 2 -0.0036475829 -0.08924031 0.07284617
## Picasso.3 Picasso 3  0.0070536563 -0.08440808 0.14208695
## Picasso.4 Picasso 4 -0.0749047538 -0.39312567 0.03233034
```

```
fitqtl.1at102.1$effects$digenic
```

```
## , , Mean
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.102.1      -0.006113424      0.0007024944      -0.01736438
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.102.1      0.003174768      0.01057042      0.01795915
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.102.1      0.006751913      -0.004667088      0.03299808
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.102.1      0.03658384      -0.03019228      -0.01170915
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.102.1      -0.03235886      0.01008722      -0.02753557
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.102.1      0.019111      -0.004468507      -0.03526626
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.102.1      -0.03957048      -0.006530542      -0.01696583
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.102.1      -0.01089652      0.02812484      -0.01162767
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.102.1      0.003223084      -0.006321676      -0.03234496
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.102.1      -0.007003255      0.02153007      0.006998187
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.102.1      0.2000931      -0.03433759      -0.03918606
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.102.1      -0.03662556      -0.004146053      0.02528288
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.102.1      -0.005221446      0.03203881      0.01029652
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.102.1      0.004928344      -0.04972305      0.1394474
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr1.102.1      -0.137852      0.1034501      0.02094793
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.102.1      0.03251599      0.0810344      -0.0101999
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.102.1      -0.01237296      -0.08820974
##
## , , Lower.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.102.1      -0.08541571      -0.07102752      -0.1910298
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.102.1      -0.0731643      -0.05239863      -0.04286095
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.102.1      -0.1042911      -0.1592298      -0.04194301
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.102.1      -0.05349572      -0.2831461      -0.2154462
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.102.1      -0.2613466      -0.09483978      -0.2471693
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.102.1      -0.04855943      -0.1477148      -0.2830185
```

```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.102.1      -0.2645143      -0.0867186      -0.1728206
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.102.1      -0.118537      -0.03408484      -0.1007537
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.102.1      -0.09240897      -0.06266504      -0.2554923
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.102.1      -0.09662436      -0.04195058      -0.05901373
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.102.1      -0.01737407      -0.2414525      -0.2894885
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.102.1      -0.2504711      -0.08388278      -0.0376316
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.102.1      -0.1130101      -0.03572116      -0.04607957
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.102.1      -0.05290006      -0.3163983      -0.02193187
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr1.102.1      -0.5484029      -0.02900821      -0.04537426
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.102.1      -0.05023052      -0.02800166      -0.12223
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.102.1      -0.1530467      -0.4410084
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr1.102.1      0.04311569      0.1071094      0.04153952
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr1.102.1      0.1287876      0.1797468      0.2062191
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr1.102.1      0.1911363      0.1384499      0.3052804
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr1.102.1      0.3444044      0.05094629      0.1410558
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr1.102.1      0.0343438      0.2041355      0.04167168
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr1.102.1      0.2438087      0.1366043      0.03806122
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr1.102.1      0.02339352      0.04711444      0.03781792
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr1.102.1      0.03545392      0.238439      0.02828416
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr1.102.1      0.1399165      0.03760013      0.02884929
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr1.102.1      0.05091981      0.2291555      0.1604061
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr1.102.1      0.5733565      0.0271074      0.03020217
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr1.102.1      0.02599334      0.07664204      0.2403358
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr1.102.1      0.08716695      0.2696633      0.1629609
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr1.102.1      0.1344406      0.0260367      0.4928885
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```

```
## chr1.102.1      0.01813287      0.4797738      0.2359767
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr1.102.1      0.3061313      0.4303883      0.04852061
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr1.102.1      0.0578958      0.02389085
```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

QTL on chr03

```
fitqtl.3at15.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.3at15,dominance=3))
fitqtl.3at15.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.3at15,dominance=4))
```

```
fitqtl.3at15.1$deltaDIC
```

```
## [1] -32.91911
```

```
fitqtl.3at15.2$deltaDIC
```

```
## [1] -33.32258
```

We accept the trigenic dominance model for the QTL on chromosome 3 at 15 cM.

```
fitqtl.3at15.1$var
```

```
##      Mean CI.lower CI.upper
## C3_5_1 additive 0.02      0.00      0.06
## C3_5_1 digenic  0.04      0.01      0.08
## C3_5_1 trigenic 0.03      0.01      0.06
## residual      0.90      0.84      0.95
```

Additive and digenic effects of parental haplotypes in the single-QTL model.

```
fitqtl.3at15.1$plots$C3_5_1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.005362278 -0.16931828 0.16959762
## Desiree.2 Desiree 2 -0.050717990 -0.31013363 0.06794490
## Desiree.3 Desiree 3  0.013153947 -0.09889251 0.22478999
## Desiree.4 Desiree 4  0.048591930 -0.06627905 0.34245569
## Electra.1 Electra 1 -0.002341929 -0.10422969 0.10483207
## Electra.2 Electra 2 -0.018522769 -0.17130203 0.07333553
## Electra.3 Electra 3  0.104690681 -0.05545873 0.45854253
## Electra.4 Electra 4  0.015417762 -0.10640061 0.25841437
## Picasso.1 Picasso 1 -0.023555118 -0.17923925 0.06028657
## Picasso.2 Picasso 2 -0.062086655 -0.33092051 0.03993690
## Picasso.3 Picasso 3  0.012554301 -0.08486019 0.18805662
## Picasso.4 Picasso 4 -0.031821881 -0.22776191 0.05998456
```

```
fitqtl.3at15.1$effects$digenic
```

```
## , , Mean
```

```
##
```

```
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C3_5_1      -0.03807282      0.02809697      -0.06964689
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C3_5_1      -0.09759307      0.189616      0.01707209
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C3_5_1      -0.02119484      -0.004784851      0.01142961
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C3_5_1      0.02667172      -0.04580605      -0.04495445
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C3_5_1      -0.01746035      -0.001812184      -0.01165574
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C3_5_1      0.00337584      -0.04418324      -0.006290677
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C3_5_1      0.03325719      -0.0481473      -0.01899207
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C3_5_1      -0.008040451      -0.03599801      -0.04331828
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C3_5_1      -0.00911573      -0.001851816      -0.03556943
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C3_5_1      0.001562659      -0.007862656      0.05871284
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C3_5_1      -0.04754056      -0.003400768      -0.01150499
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C3_5_1      -0.03801898      -0.02851917      0.0005811916
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C3_5_1      0.01655809      -0.007783429      0.01699538
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C3_5_1      0.003011731      -0.0346777      -0.04650256
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C3_5_1      -0.01638931      -0.03154571      0.1356257
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C3_5_1      0.06691695      0.3780704      -0.0453711
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C3_5_1      -0.01543098      0.01259087
```

```
##
```

```
## , , Lower.CI
```

```
##
```

```
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C3_5_1      -0.2931302      -0.05252296      -0.3886671
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C3_5_1      -0.4603402      -0.02742808      -0.06078844
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C3_5_1      -0.2095446      -0.135876      -0.08117601
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C3_5_1      -0.07442245      -0.3326204      -0.3485573
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C3_5_1      -0.1841782      -0.1059811      -0.1573639
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C3_5_1      -0.09761733      -0.3121932      -0.139877
```

```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C3_5_1      -0.04426314      -0.290618      -0.1520444
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C3_5_1      -0.06929376      -0.2577465      -0.2691496
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C3_5_1      -0.1217094      -0.08260754      -0.2338522
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C3_5_1      -0.06224774      -0.07552085      -0.03986966
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C3_5_1      -0.2978722      -0.1039764      -0.1309629
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C3_5_1      -0.2687369      -0.2236973      -0.06940579
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C3_5_1      -0.04950673      -0.1067071      -0.05625852
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C3_5_1      -0.06684392      -0.2531275      -0.2909375
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C3_5_1      -0.1696198      -0.2555362      -0.03454047
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C3_5_1      -0.04275447      -0.01159895      -0.3024186
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C3_5_1      -0.1654013      -0.05828045
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C3_5_1      0.05556172      0.2916249      0.0256607
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C3_5_1      0.02126759      0.5839508      0.2536356
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C3_5_1      0.09853376      0.1582302      0.2388093
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C3_5_1      0.3062178      0.04806516      0.07726001
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C3_5_1      0.1039629      0.1571806      0.1177375
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C3_5_1      0.1837306      0.04022437      0.157267
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C3_5_1      0.2858141      0.027362      0.04082429
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C3_5_1      0.06817673      0.03927995      0.02924086
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C3_5_1      0.09996201      0.1363309      0.02924237
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C3_5_1      0.1483329      0.08928868      0.329143
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C3_5_1      0.03140208      0.1459627      0.08961605
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C3_5_1      0.03714679      0.04280836      0.1432585
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C3_5_1      0.2193573      0.107157      0.242123
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C3_5_1      0.169271      0.03381532      0.02666204
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```

```
## C3_5_1          0.08910474          0.05890989          0.5050793
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C3_5_1          0.3828725          0.7433674          0.03403041
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C3_5_1          0.0990176          0.2243318
```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

```
# QTL on chr04
```

```
fitqtl.4at0.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.4at0,dominance=3))
fitqtl.4at0.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.4at0,dominance=4))
```

```
fitqtl.4at0.1$deltaDIC
```

```
## [1] -33.38433
```

```
fitqtl.4at0.2$deltaDIC
```

```
## [1] -31.46607
```

We accept the trigenic dominance model for the QTL on chromosome 4 at 0 cM.

```
fitqtl.4at0.1$var
```

```
##              Mean CI.lower CI.upper
## C4_1_1 additive 0.02      0.00      0.05
## C4_1_1 digenic  0.03      0.01      0.06
## C4_1_1 trigenic 0.04      0.02      0.06
## residual        0.91      0.87      0.95
```

```
### Additive and digenic effects of parental haplotypes in the single-QTL model.
```

```
fitqtl.4at0.1$plots$C4_1_1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.008745800 -0.08392418 0.09600662
## Desiree.2 Desiree 2 -0.018656265 -0.09808346 0.05103750
## Desiree.3 Desiree 3 -0.020929577 -0.11752365 0.05365503
## Desiree.4 Desiree 4 -0.008740221 -0.08553106 0.09436372
## Electra.1 Electra 1  0.005846694 -0.07852445 0.17684765
## Electra.2 Electra 2  0.018601372 -0.07151454 0.26260296
## Electra.3 Electra 3 -0.037547886 -0.27480174 0.06869080
## Electra.4 Electra 4  0.191163812 -0.02995117 0.61625175
## Picasso.1 Picasso 1 -0.052962002 -0.27950305 0.02621757
## Picasso.2 Picasso 2 -0.022419867 -0.11915974 0.05087683
## Picasso.3 Picasso 3 -0.002366366 -0.08120460 0.13890464
## Picasso.4 Picasso 4 -0.043243892 -0.24945939 0.03601017
```



```
fitqtl.4at0.1$effects$digenic
```

```
## , , Mean
```

```
##
```

```
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C4_1_1      -0.003929625      -0.005301246      -0.006391224
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C4_1_1      0.006854979      -0.01162874      -0.01001504
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C4_1_1      0.01061024      0.007076266      -0.02686138
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C4_1_1      -0.04098035      0.06175006      0.01559681
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C4_1_1      -0.0199331      0.003300408      -0.09433378
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C4_1_1      -0.00773287      -0.0005352587      -0.001378967
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C4_1_1      -0.01334002      -0.01742723      -0.03275574
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C4_1_1      0.004347288      0.00126615      -0.006922728
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C4_1_1      -0.0276657      -0.008372614      0.0972141
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C4_1_1      -0.006109095      -0.002577378      -0.03090544
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C4_1_1      -0.006420671      -0.02118684      -0.01781835
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C4_1_1      0.004864527      -0.01915991      0.0191891
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C4_1_1      0.008730868      -0.002140073      -0.0149193
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C4_1_1      0.02220963      -0.01425986      0.02360005
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C4_1_1      -0.06276486      0.0196975      0.07571819
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C4_1_1      -0.04013239      0.194966      -0.04221609
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C4_1_1      -0.01202132      0.09765875
```

```
##
```

```
## , , Lower.CI
```

```
##
```

```
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C4_1_1      -0.05253277      -0.05602213      -0.07926088
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C4_1_1      -0.03996414      -0.1123599      -0.08749843
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C4_1_1      -0.06863913      -0.1146057      -0.2660142
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C4_1_1      -0.3227311      -0.03725571      -0.07035332
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C4_1_1      -0.2065952      -0.06616507      -0.4619336
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C4_1_1      -0.104457      -0.07268074      -0.08787249
```

```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C4_1_1      -0.1263845      -0.1320581      -0.2347671
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C4_1_1      -0.05003245      -0.04329021      -0.06427333
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C4_1_1      -0.2121047      -0.08345761      -0.02476385
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C4_1_1      -0.06017359      -0.05033965      -0.2175598
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C4_1_1      -0.1042171      -0.1700275      -0.1374088
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C4_1_1      -0.04627683      -0.1720848      -0.041823
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C4_1_1      -0.04462481      -0.06145539      -0.1527331
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C4_1_1      -0.03820459      -0.1480363      -0.03830002
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C4_1_1      -0.3771695      -0.04366409      -0.02755916
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C4_1_1      -0.2808113      -0.02024523      -0.3212449
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C4_1_1      -0.124631      -0.02726051
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C4_1_1      0.05881546      0.04578074      0.05784757
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C4_1_1      0.140459      0.03719818      0.03220127
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C4_1_1      0.2084053      0.2275586      0.05598958
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C4_1_1      0.03010175      0.432983      0.2617124
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C4_1_1      0.05781443      0.1444151      0.02242067
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C4_1_1      0.07633803      0.1101024      0.1223496
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C4_1_1      0.03259119      0.02440248      0.02249228
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C4_1_1      0.1247942      0.09804998      0.03658748
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C4_1_1      0.02369175      0.04007846      0.3891693
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C4_1_1      0.03990912      0.06713315      0.02181964
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C4_1_1      0.0743361      0.02481527      0.02375013
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C4_1_1      0.1426249      0.02829562      0.2331227
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C4_1_1      0.1643398      0.09083355      0.04094849
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C4_1_1      0.2387799      0.04841583      0.2497006
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```

```
## C4_1_1          0.02041745          0.2442925          0.3924035
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C4_1_1          0.02380437          0.5960986          0.03067726
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C4_1_1          0.04766834          0.4508254
```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

QTL on chr08

```
fitqtl.8at48.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.8at48,dominance=3))
fitqtl.8at48.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.8at48,dominance=4))
```

```
fitqtl.8at48.1$deltaDIC
```

```
## [1] -37.07367
```

```
fitqtl.8at48.2$deltaDIC
```

```
## [1] -32.76733
```

We accept the trigenic dominance model for the QTL on chromosome 8 at 48 cM.

```
fitqtl.8at48.1$var
```

```
##              Mean CI.lower CI.upper
## chr8.48.1 additive 0.01      0.00      0.04
## chr8.48.1 digenic  0.03      0.01      0.07
## chr8.48.1 trigenic 0.05      0.02      0.08
## residual           0.91      0.85      0.94
```

Additive and digenic effects of parental haplotypes in the single-QTL model.

```
fitqtl.8at48.1$plots$chr8.48.1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.001683174 -0.07024834 0.07078992
## Desiree.2 Desiree 2  0.007873359 -0.05848382 0.11237791
## Desiree.3 Desiree 3 -0.008737534 -0.12292034 0.06594042
## Desiree.4 Desiree 4 -0.017991880 -0.20131090 0.06535472
## Electra.1 Electra 1  0.034318977 -0.04987208 0.29066012
## Electra.2 Electra 2 -0.001061612 -0.12245575 0.11234718
## Electra.3 Electra 3  0.036330221 -0.04836635 0.30106736
## Electra.4 Electra 4  0.007828102 -0.08405196 0.15250311
## Picasso.1 Picasso 1 -0.011718033 -0.17942856 0.07800108
## Picasso.2 Picasso 2  0.002525083 -0.06883728 0.08038661
## Picasso.3 Picasso 3 -0.017507427 -0.19036038 0.06892475
## Picasso.4 Picasso 4 -0.030176083 -0.24444736 0.04313458
```

```
fitqtl.8at48.1$effects$digenic
```

```
## , , Mean
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.48.1      0.02208734      -0.02196517      -0.06067546
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.48.1      -0.0170957      0.0007862686      0.01904202
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.48.1      0.01302544      -0.01663048      0.04237888
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.48.1      0.01063841      -0.04993227      0.006927462
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.48.1      -0.01141148      -0.0006097065      -0.03440145
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.48.1      -0.01030184      0.008221692      -0.02764265
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.48.1      -0.04159129      0.04884441      -0.04263061
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.48.1      -0.001985689      -0.01807147      0.01891809
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.48.1      -0.05456724      0.02652002      -0.03965738
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.48.1      -0.001764861      0.03273966      -0.06532525
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.48.1      -0.00172552      -0.01668433      -0.04248865
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.48.1      -0.01440469      0.01118343      -0.0002182156
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.48.1      0.1314395      -0.0115487      0.0329024
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.48.1      -0.07744918      0.0392905      -0.03519138
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr8.48.1      0.02584109      -0.03387506      -0.01437831
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.48.1      0.2049541      -0.006916232      0.0561224
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.48.1      -0.002135151      -0.05531423
##
## , , Lower.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.48.1      -0.04767704      -0.1956871      -0.3639526
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.48.1      -0.1957937      -0.1277069      -0.06025972
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.48.1      -0.08627452      -0.2037281      -0.0540494
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.48.1      -0.0981456      -0.3656882      -0.1162466
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.48.1      -0.1712414      -0.1485251      -0.2835791
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.48.1      -0.1662626      -0.08856528      -0.2487358
```

```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.48.1      -0.2876474      -0.03814004      -0.2956163
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.48.1      -0.1030734      -0.1624421      -0.04732341
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.48.1      -0.3203878      -0.04139737      -0.2749394
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.48.1      -0.1033708      -0.04357483      -0.3766549
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.48.1      -0.0705287      -0.1707114      -0.2877096
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.48.1      -0.1398638      -0.05341832      -0.09124331
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.48.1      -0.02960749      -0.1461316      -0.04178697
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.48.1      -0.423372      -0.04498558      -0.2895715
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr8.48.1      -0.04302077      -0.2681147      -0.1839129
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.48.1      -0.02098377      -0.1295783      -0.03926191
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.48.1      -0.1258337      -0.3794552
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.48.1      0.2455862      0.04148455      0.02917317
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.48.1      0.05700424      0.16748      0.2464897
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.48.1      0.2234687      0.09986664      0.373516
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.48.1      0.2305521      0.03983623      0.2182751
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.48.1      0.0995126      0.1834474      0.03774208
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.48.1      0.09385247      0.1959152      0.04293348
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.48.1      0.03117573      0.3364597      0.03283153
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.48.1      0.1137886      0.03647506      0.2253151
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.48.1      0.02415364      0.2621931      0.02998905
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.48.1      0.1216378      0.2960968      0.02779352
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.48.1      0.0845345      0.05096353      0.03132845
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.48.1      0.04030323      0.1840601      0.1332087
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.48.1      0.5072272      0.07532635      0.2972724
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.48.1      0.02604849      0.3359481      0.03778041
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```

```
## chr8.48.1          0.2510426          0.03836767          0.08725869
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.48.1          0.5699637          0.09880957          0.3734551
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.48.1          0.1393267          0.03386081
```

No additive effect or digenic effect of any single parental haplotype or diplotype at this QTL is significantly different than zero at alpha 0.1.

```
# 2nd QTL on chr08

fitqtl.8at80.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.8at80,dominance=3))
fitqtl.8at80.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.8at80,dominance=4))
```

```
fitqtl.8at80.1$deltaDIC
```

```
## [1] -18.36132
```

```
fitqtl.8at80.2$deltaDIC
```

```
## [1] -20.83095
```

As none of the higher dominance model had a DIC at least 10 points lower, we accept the QTL refinement model (dom = 2) for this QTL on chromosome 8 at 80 cM.

```
fitqtl.8at80 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                      qtl = data.frame(marker=qtl.8at80,dominance=2))
```

```
fitqtl.8at80$var
```

```
##
##      Mean CI.lower CI.upper
## chr8.80.1 additive 0.02      0.00      0.04
## chr8.80.1 digenic  0.04      0.02      0.06
## residual           0.95      0.91      0.97
```

```
### Additive and digenic effects of parental haplotypes in the single-QTL model.
fitqtl.8at80$plots$chr8.80.1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1 -0.126374028 -0.41810204 0.02643708
## Desiree.2 Desiree 2  0.005655391 -0.05954205 0.06694862
## Desiree.3 Desiree 3  0.030790310 -0.03722737 0.18819865
## Desiree.4 Desiree 4  0.008432175 -0.05035840 0.06915450
## Electra.1 Electra 1  0.023502991 -0.04444669 0.17969749
## Electra.2 Electra 2  0.006563661 -0.06044102 0.07031382
## Electra.3 Electra 3  0.084103047 -0.02302929 0.40523703
## Electra.4 Electra 4  0.002472568 -0.06979053 0.06815092
## Picasso.1 Picasso 1  0.015057133 -0.04721553 0.10810599
## Picasso.2 Picasso 2 -0.014358840 -0.22591684 0.06511341
## Picasso.3 Picasso 3 -0.016948698 -0.16608767 0.04919411
## Picasso.4 Picasso 4 -0.018895711 -0.18583891 0.04449464
```

```
fitqtl.8at80$effects$digenic
```

```
## , , Mean
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.80.1      0.00513143      -0.01377253      -0.02039024
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.80.1      0.003455462      0.0005891476      0.0276952
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.80.1      0.007262802      -0.04361655      0.0341354
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.80.1      0.07156198      -0.08108242      0.02533554
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.80.1      0.01418858      0.0135791      -0.02313263
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.80.1      -0.03778646      0.01024046      -0.04996765
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.80.1      -0.2145452      0.08289107      0.01081538
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.80.1      0.0005093684      -0.007089518      -0.004490967
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.80.1      -0.2537471      0.0839427      -0.007612274
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.80.1      -0.004163013      0.01489232      -0.01990957
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.80.1      -0.236181      -0.005324501      0.01610225
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.80.1      0.003857197      -0.006922155      0.01358331
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.80.1      0.008383419      0.02019809      0.0210357
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.80.1      -0.05051234      0.02388795      0.006092894
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr8.80.1      0.09699253      0.02085285      0.03587824
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.80.1      -0.02208369      0.01006458      0.01856982
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.80.1      -0.00349758      0.003886153
##
## , , Lower.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.80.1      -0.04525824      -0.1748238      -0.2010579
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.80.1      -0.04666293      -0.07673609      -0.02491596
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.80.1      -0.06068769      -0.3584539      -0.0278947
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.80.1      -0.0235653      -0.4127653      -0.03445519
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.80.1      -0.04026382      -0.03451291      -0.2409734
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.80.1      -0.2800113      -0.04668442      -0.3048228
```

```

##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.80.1      -0.4702571      -0.01678787      -0.0272945
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.80.1      -0.04797444      -0.1299148      -0.1018952
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.80.1      -0.4653505      -0.01782103      -0.1369374
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.80.1      -0.09369968      -0.02833053      -0.1923946
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.80.1      -0.4790816      -0.1042248      -0.02905023
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.80.1      -0.03950772      -0.1560016      -0.03621737
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.80.1      -0.03712075      -0.02853394      -0.03684976
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.80.1      -0.3118546      -0.0265281      -0.04069074
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## chr8.80.1      -0.02158142      -0.03387542      -0.02858748
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.80.1      -0.2444966      -0.04805407      -0.03011365
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.80.1      -0.0998361      -0.05325653
##
## , , Upper.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## chr8.80.1      0.05527457      0.03468067      0.0325133
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## chr8.80.1      0.04653848      0.04489466      0.2053238
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## chr8.80.1      0.1033871      0.0382329      0.2615052
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## chr8.80.1      0.3792885      0.02736914      0.2268696
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## chr8.80.1      0.1546816      0.130674      0.03578886
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## chr8.80.1      0.03068066      0.12044      0.02714291
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## chr8.80.1      0.01028606      0.3253508      0.07517568
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## chr8.80.1      0.03698976      0.03662585      0.03628522
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## chr8.80.1      0.005151864      0.3580878      0.03718116
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## chr8.80.1      0.03546197      0.1150919      0.03213387
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## chr8.80.1      0.01078472      0.03543107      0.1249894
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## chr8.80.1      0.04342659      0.04602307      0.1282092
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## chr8.80.1      0.08598974      0.1648243      0.1931884
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## chr8.80.1      0.0291061      0.1888732      0.05952123
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3

```



```
## chr8.80.1          0.4322916          0.1901036          0.2529837
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## chr8.80.1          0.0373305          0.1187666          0.1642828
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## chr8.80.1          0.04053164         0.0524272
```

No additive effect or digenic effect of any single parental haplotpe or diplotype at this QTL is significantly different than zero at alpha 0.1.

###marker on chr10

```
fitqtl.10at69.1 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at69,dominance=3))
fitqtl.10at69.2 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at69,dominance=4))
```

```
fitqtl.10at69.1$deltaDIC
```

```
## [1] -41.11278
```

```
fitqtl.10at69.2$deltaDIC
```

```
## [1] -37.9883
```

We accept the discovery model (dom = 2) for the QTL on chromosome 10 at 64 cM.

```
fitqtl.10at69 <- fitQTL(data = data_cs, trait = "Common.scab", params = params,
                        qtl = data.frame(marker=qtl.10at69,dominance=2))
```

```
fitqtl.10at69$var
```

```
##              Mean CI.lower CI.upper
## C10_16_1 additive 0.01      0.00      0.04
## C10_16_1 digenic  0.05      0.02      0.08
## residual          0.94      0.91      0.96
```

Additive and digenic effects of parental haplotypes in the single-QTL model.

```
fitqtl.10at69$plots$C10_16_1$additive$data
```

```
##      parent x      mean  CI.lower  CI.upper
## Desiree.1 Desiree 1  0.0196282246 -0.05580443 0.20460258
## Desiree.2 Desiree 2 -0.0284073541 -0.14954183 0.03198021
## Desiree.3 Desiree 3 -0.0147543805 -0.07126312 0.04027621
## Desiree.4 Desiree 4 -0.0172652055 -0.07664509 0.03963433
## Electra.1 Electra 1 -0.0513448805 -0.25734965 0.01957782
## Electra.2 Electra 2 -0.0212632697 -0.10156464 0.04015619
## Electra.3 Electra 3  0.1829629550 -0.02612010 0.53044822
## Electra.4 Electra 4 -0.0001598524 -0.06439368 0.13663643
## Picasso.1 Picasso 1 -0.0409087316 -0.24824818 0.02890068
## Picasso.2 Picasso 2  0.0047646770 -0.05698914 0.15874676
## Picasso.3 Picasso 3 -0.0211926373 -0.12443453 0.04629865
## Picasso.4 Picasso 4 -0.0120595449 -0.06903711 0.04980735
```

```
fitqtl.10at69$effects$digenic
```

```
## , , Mean
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C10_16_1      0.008346693      0.03245402      0.03268293
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C10_16_1     -0.008686617      0.001220186     -0.01803378
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C10_16_1     -0.03074254      0.007043451     -0.03684531
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C10_16_1      0.01244841      0.04515975      0.03576809
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C10_16_1      0.03663031     -0.05319819      0.006229532
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C10_16_1      0.0406173      -0.01891299      0.01410501
##      Desiree.1+Picasso.1 Desiree.2+Picasso.1 Desiree.3+Picasso.1
## C10_16_1      0.01979589     -0.04939575      0.001578548
##      Desiree.4+Picasso.1 Desiree.1+Picasso.2 Desiree.2+Picasso.2
## C10_16_1     -0.2330822      0.06427532     -0.01190542
##      Desiree.3+Picasso.2 Desiree.4+Picasso.2 Desiree.1+Picasso.3
## C10_16_1     -0.006150783      0.02158117      0.05566964
##      Desiree.2+Picasso.3 Desiree.3+Picasso.3 Desiree.4+Picasso.3
## C10_16_1     -0.001553068     -0.0910837      -0.007552646
##      Desiree.1+Picasso.4 Desiree.2+Picasso.4 Desiree.3+Picasso.4
## C10_16_1      0.02663949     -0.01353262     -0.01178457
##      Desiree.4+Picasso.4 Desiree.1+Electra.1 Desiree.2+Electra.1
## C10_16_1     -0.00417609     -0.01897059     -0.00595359
##      Desiree.3+Electra.1 Desiree.4+Electra.1 Desiree.1+Electra.2
## C10_16_1     -0.01965441     -0.01400081     -0.03696968
##      Desiree.2+Electra.2 Desiree.3+Electra.2 Desiree.4+Electra.2
## C10_16_1      0.001388573      0.06545747     -0.03444955
##      Desiree.1+Electra.3 Desiree.2+Electra.3 Desiree.3+Electra.3
## C10_16_1     -0.01447745      0.1209486      -0.03971781
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C10_16_1      0.148359      -0.01191255     -0.006736749
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C10_16_1      0.04605233      0.4900347
##
## , , Lower.CI
##
##      Desiree.1+Desiree.2 Desiree.1+Desiree.3 Desiree.1+Desiree.4
## C10_16_1     -0.03379837     -0.02989687     -0.02940218
##      Desiree.2+Desiree.3 Desiree.2+Desiree.4 Desiree.3+Desiree.4
## C10_16_1     -0.08886315     -0.03881935     -0.1533744
##      Electra.1+Electra.2 Electra.1+Electra.3 Electra.1+Electra.4
## C10_16_1     -0.2446862     -0.1002773     -0.2771276
##      Electra.2+Electra.3 Electra.2+Electra.4 Electra.3+Electra.4
## C10_16_1     -0.04918541     -0.03538062     -0.03527029
##      Picasso.1+Picasso.2 Picasso.1+Picasso.3 Picasso.1+Picasso.4
## C10_16_1     -0.03258687     -0.3316545     -0.04347602
##      Picasso.2+Picasso.3 Picasso.2+Picasso.4 Picasso.3+Picasso.4
## C10_16_1     -0.1070978     -0.1847943     -0.04152975
```

##	Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1
## C10_16_1	-0.03143615	-0.2570189	-0.03866177
##	Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2
## C10_16_1	-0.4325485	-0.02782673	-0.1087072
##	Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3
## C10_16_1	-0.05970036	-0.03143134	-0.02913298
##	Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3
## C10_16_1	-0.04772591	-0.3615973	-0.07878666
##	Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4
## C10_16_1	-0.0308043	-0.105944	-0.09733595
##	Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1
## C10_16_1	-0.04152975	-0.1678341	-0.06810543
##	Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2
## C10_16_1	-0.1801994	-0.1421319	-0.257948
##	Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2
## C10_16_1	-0.03830811	-0.02672959	-0.2362004
##	Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3
## C10_16_1	-0.1814479	-0.02321167	-0.3040916
##	Desiree.4+Electra.3	Desiree.1+Electra.4	Desiree.2+Electra.4
## C10_16_1	-0.02108345	-0.1137299	-0.07592581
##	Desiree.3+Electra.4	Desiree.4+Electra.4	
## C10_16_1	-0.03040718	0.2391725	
##			
##	, , Upper.CI		
##			
##	Desiree.1+Desiree.2	Desiree.1+Desiree.3	Desiree.1+Desiree.4
## C10_16_1	0.1250323	0.245546	0.2449534
##	Desiree.2+Desiree.3	Desiree.2+Desiree.4	Desiree.3+Desiree.4
## C10_16_1	0.03376181	0.06979385	0.02828827
##	Electra.1+Electra.2	Electra.1+Electra.3	Electra.1+Electra.4
## C10_16_1	0.03103604	0.1911459	0.02831146
##	Electra.2+Electra.3	Electra.2+Electra.4	Electra.3+Electra.4
## C10_16_1	0.2003104	0.3472171	0.3116979
##	Picasso.1+Picasso.2	Picasso.1+Picasso.3	Picasso.1+Picasso.4
## C10_16_1	0.290386	0.02664537	0.1298407
##	Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4
## C10_16_1	0.4256269	0.03400439	0.1888426
##	Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1
## C10_16_1	0.1875065	0.0216325	0.0654176
##	Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2
## C10_16_1	-0.0007586763	0.3457899	0.03120228
##	Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3
## C10_16_1	0.03946686	0.1994873	0.318659
##	Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3
## C10_16_1	0.06058742	0.01822112	0.03645909
##	Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4
## C10_16_1	0.2058746	0.02655143	0.02883687
##	Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1
## C10_16_1	0.03351392	0.02943463	0.03643062
##	Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2
## C10_16_1	0.03171956	0.0323124	0.02643732
##	Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2
## C10_16_1	0.06130815	0.3362651	0.02534041
##	Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3

```
## C10_16_1          0.07029226          0.4319087          0.03045272
##      Desiree.4+Electra.3 Desiree.1+Electra.4 Desiree.2+Electra.4
## C10_16_1          0.4812467          0.03356362          0.03990952
##      Desiree.3+Electra.4 Desiree.4+Electra.4
## C10_16_1          0.318177          0.7280822
```

No additive effect of any single parental haplotype at this QTL is significantly different than zero at alpha 0.1. However, the diplotypes Desiree.4+Picasso.1 and Desiree.4+Electra.4 have an effect significantly different than zero at alpha 0.1.

Multi-QTL model

Multi-QTL model built using backward elimination. Markers whose presence increased the DIC were eliminated one by one, starting with the marker that increased the DIC the most.

```
Original_df <- data.frame(marker=c(qtl.4at14,qtl.5at34,qtl.10at29,
    qtl.12at1.23,qtl.1at2,qtl.3at15,qtl.4at0,qtl.8at80,
    qtl.10at69,qtl.1at102, qtl.8at48),
    dominance = c(1,1,4,3,4,3,3,2,2,3,3))
```

```
set_params(data_cs, trait = "Common.scab", q=0.05, r=0.025, qtl = Original_df)
```

```
##      burnIn nIter
## chr4.14.1 additive      16  1342
## chr5.34.1 additive      18  1512
## chr10.29.1 additive     14  1278
## chr10.29.1 digenic      12  1118
## chr10.29.1 trigenic     16  1516
## chr10.29.1 quadrigenic  15  1554
## C12_2_2 additive       20  1542
## C12_2_2 digenic        12  1008
## C12_2_2 trigenic       12  1110
## chr1.2.1 additive      12  1110
## chr1.2.1 digenic       11   926
## chr1.2.1 trigenic      15  1554
## chr1.2.1 quadrigenic   12  1052
## C3_5_1 additive       20  1692
## C3_5_1 digenic        18  1644
## C3_5_1 trigenic       12  1166
## C4_1_1 additive       18  1434
## C4_1_1 digenic        10  1080
## C4_1_1 trigenic        6   568
## chr8.80.1 additive     17  1460
## chr8.80.1 digenic      14  1334
## C10_16_1 additive     20  1692
## C10_16_1 digenic      14   996
## chr1.102.1 additive     7   651
## chr1.102.1 digenic     14  1166
## chr1.102.1 trigenic    21  1872
## chr8.48.1 additive     11   900
## chr8.48.1 digenic      12   946
## chr8.48.1 trigenic     21  1620
## residual               3   342
```

```

params <- list(burnIn=1000,nIter=40000)

# 1st model: includes all QTLs
df <- data.frame(marker=c(qtl.4at14,qtl.5at34,qtl.10at29,
                        qtl.12at1.23,qtl.1at2,qtl.3at15,qtl.4at0,qtl.8at80,
                        qtl.10at69,qtl.1at102, qtl.8at48),
                dominance = c(1,1,4,3,4,3,3,2,2,3,3))

full_model <- fitQTL(data=data_cs, trait="Common.scab", params=params, qtl = df)

DIC <- NULL
for (i in 1:11) {
  redm <- fitQTL(data=data_cs, trait="Common.scab", params=params, qtl = df[-i,])
  DIC <- rbind(DIC, redm$deltaDIC)
  dif <- -fullm$deltaDIC + DIC
}

```

```
dif
```

```

##           [,1]
## [1,]  0.32747493
## [2,] -0.08169894
## [3,] -0.59050815
## [4,] 21.73846531
## [5,]  8.64181233
## [6,]  7.00331407
## [7,] -0.61713865
## [8,]  9.63314104
## [9,]  6.67192628
## [10,] -4.75863499
## [11,]  0.77816539

```

We take out the QTL on chr 1 at 102 cM (qtl.1at102) from the dataframe and repeat the process until all the QTLs left in the model contribute at least 10 points to lower the DIC.

```

# Final model: retained 5 QTLs and all lowered the DIC by at least 10 points.

df <- data.frame(marker=c(qtl.12at1.23,qtl.1at2,qtl.3at15,qtl.8at80,qtl.10at69),
                dominance = c(3,4,3,2,2))

new_full_model <- fitQTL(data=data_cs, trait="Common.scab", params=params, qtl = df)

```

```
new_full_model$deltaDIC
```

```
## [1] -193.1578
```

We test whether including the polygenic effect reduces the DIC.

```
new_full_model_POL <- fitQTL(data=data_cs, trait="Common.scab", params=params,
                             qtl = df, polygenic = TRUE)
```

```
new_full_model_POL$deltaDIC
```

```
## [1] -196.1443
```

We accept the model without polygenic effect.

```
new_full_model$var
```

```
##               Mean CI.lower CI.upper
## C12_2_2 additive    0.02     0.00     0.06
## C12_2_2 digenic     0.03     0.01     0.05
## C12_2_2 trigenic    0.03     0.01     0.05
## chr1.2.1 additive   0.01     0.00     0.04
## chr1.2.1 digenic    0.02     0.01     0.04
## chr1.2.1 trigenic   0.02     0.01     0.05
## chr1.2.1 quadrigenic 0.03     0.01     0.05
## C3_5_1 additive     0.02     0.00     0.04
## C3_5_1 digenic      0.02     0.01     0.05
## C3_5_1 trigenic     0.02     0.01     0.04
## chr8.80.1 additive  0.02     0.00     0.04
## chr8.80.1 digenic   0.02     0.01     0.04
## C10_16_1 additive   0.02     0.00     0.05
## C10_16_1 digenic    0.03     0.01     0.06
## residual            0.69     0.62     0.75
```

```
sum(new_full_model$var[-15,1])
```

```
## [1] 0.31
```

The multi-QTL model explains 31% of the total variance.

```
### Additive and digenic effects of parental haplotypes for the QTL in the multi-QTL model.
```

```
new_full_model$effects$Additive
```

```
## , , Mean
```

```
##
```

```
##           Desiree.1  Desiree.2  Desiree.3  Desiree.4  Electra.1
## C12_2_2  -0.013130901 -0.040665947  0.0748441372 -0.006365149  0.05306069
## chr1.2.1 -0.055656868 -0.001628564  0.0336021658  0.008987306 -0.01418571
## C3_5_1   -0.004200468 -0.081748609 -0.0007527832  0.091438293 -0.05095115
## chr8.80.1 -0.182323807  0.017016189  0.0353729048  0.017595479  0.01709290
## C10_16_1  0.034623116 -0.018660880 -0.0193120064  0.019993378 -0.20676090
##           Electra.2  Electra.3  Electra.4  Picasso.1  Picasso.2
## C12_2_2  -0.04214174  0.03360862 -0.010470759 -0.007030399 -0.125009064
## chr1.2.1  0.01184976  0.03586082 -0.004977619  0.016140692  0.002855551
## C3_5_1   -0.02255168  0.07571758  0.018824518 -0.002539246 -0.024608832
## chr8.80.1 -0.01572307  0.09474493 -0.001372443  0.038525461  0.005578795
## C10_16_1 -0.01540844  0.16392926  0.051365894 -0.042610893  0.060349001
##           Picasso.3  Picasso.4
## C12_2_2    0.087385259 -0.004084744
## chr1.2.1   -0.010774377 -0.022073158
```

```
## C3_5_1      0.023333524 -0.021961147
## chr8.80.1   0.008423298 -0.034930646
## C10_16_1    -0.016590865 -0.010916669
##
## , , Lower.CI
##
##           Desiree.1  Desiree.2  Desiree.3  Desiree.4  Electra.1
## C12_2_2    -0.19540713 -0.27242301 -0.06226596 -0.17235541 -0.07241976
## chr1.2.1   -0.30443465 -0.14303621 -0.06844112 -0.11102958 -0.22787611
## C3_5_1     -0.13557906 -0.33122963 -0.11725187 -0.04719756 -0.30574898
## chr8.80.1  -0.39994272 -0.08737987 -0.05097174 -0.07660395 -0.11373319
## C10_16_1   -0.07939675 -0.16957951 -0.17834632 -0.09198266 -0.52490441
##           Electra.2  Electra.3  Electra.4  Picasso.1  Picasso.2  Picasso.3
## C12_2_2    -0.2934946 -0.09056945 -0.19836469 -0.20147459 -0.4807204 -0.06241751
## chr1.2.1   -0.1390914 -0.10142131 -0.19400964 -0.11234375 -0.1375499 -0.19471957
## C3_5_1     -0.2315500 -0.05513306 -0.11434609 -0.14027346 -0.2096128 -0.09158485
## chr8.80.1  -0.2104846 -0.03175362 -0.17637038 -0.06390142 -0.1428850 -0.11189788
## C10_16_1   -0.2084542 -0.02849660 -0.07777358 -0.29789832 -0.0685442 -0.20136871
##           Picasso.4
## C12_2_2    -0.1878358
## chr1.2.1   -0.2187547
## C3_5_1     -0.1946399
## chr8.80.1  -0.2520748
## C10_16_1   -0.1813100
##
## , , Upper.CI
##
##           Desiree.1  Desiree.2  Desiree.3  Desiree.4  Electra.1  Electra.2
## C12_2_2    0.12012423 0.08044492 0.35161970 0.1288680 0.30745348 0.09083261
## chr1.2.1   0.05521417 0.13232564 0.24365555 0.1652231 0.14004117 0.20623203
## C3_5_1     0.12459098 0.04292751 0.12450399 0.3508017 0.07233752 0.11999883
## chr8.80.1  0.01762777 0.14333829 0.19283636 0.1303893 0.17083521 0.08546816
## C10_16_1   0.21675981 0.08111328 0.08323099 0.1883937 0.01947063 0.12540369
##           Electra.3  Electra.4  Picasso.1  Picasso.2  Picasso.3  Picasso.4
## C12_2_2    0.2533578 0.1329695 0.15541909 0.05643148 0.4163304 0.15626370
## chr1.2.1   0.2952150 0.1587039 0.21514928 0.15237829 0.1239639 0.08352295
## C3_5_1     0.3513570 0.2301802 0.13521435 0.08717967 0.2257081 0.08596112
## chr8.80.1  0.3601387 0.1271862 0.21971066 0.13823911 0.1176732 0.06657781
## C10_16_1   0.4750009 0.3004441 0.08726705 0.30185971 0.1132869 0.11517397
```

```
new_full_model$effects$digenic
```

```
## , , Mean
##
##           Desiree.1+Desiree.2  Desiree.1+Desiree.3  Desiree.1+Desiree.4
## C12_2_2                      -0.026781701          -0.001696718          0.08447446
## chr1.2.1                     -0.035096126          -0.002148132          -0.04786627
## C3_5_1                       -0.015429547           0.035741356          -0.03152513
## chr8.80.1                    -0.005663902          -0.025916243          -0.01608497
## C10_16_1                     0.031520968           0.021446677           0.07902204
##           Desiree.2+Desiree.3  Desiree.2+Desiree.4  Desiree.3+Desiree.4
## C12_2_2                      0.014757186          -0.016801031          0.01566394
## chr1.2.1                     0.029954218           0.013979397           0.01108923
## C3_5_1                       -0.059382811           0.063929471           0.01817881
```

## chr8.80.1	0.003892872	-0.011842284	0.03991057
## C10_16_1	-0.004080964	0.006604391	-0.02257888
## Electra.1+Electra.2	Electra.1+Electra.3	Electra.1+Electra.4	
## C12_2_2	0.01727168	0.008040409	-0.012689274
## chr1.2.1	0.05546824	-0.020862309	-0.086862463
## C3_5_1	-0.02035947	-0.017473806	0.007843172
## chr8.80.1	-0.02804267	0.041567363	-0.005755325
## C10_16_1	-0.05307431	-0.005304258	-0.006674718
## Electra.2+Electra.3	Electra.2+Electra.4	Electra.3+Electra.4	
## C12_2_2	0.042231080	-0.0070502783	0.0082947208
## chr1.2.1	-0.024819141	0.0185924967	0.0698974461
## C3_5_1	0.043329109	-0.0282007944	0.0153204678
## chr8.80.1	0.002816438	-0.0009613687	0.0004019955
## C10_16_1	0.061201460	0.0242680887	0.0215587820
## Picasso.1+Picasso.2	Picasso.1+Picasso.3	Picasso.1+Picasso.4	
## C12_2_2	-0.024473873	0.006123869	0.017906915
## chr1.2.1	0.011495960	-0.028465868	0.014889148
## C3_5_1	-0.002832589	-0.005613268	0.006051228
## chr8.80.1	-0.011096064	0.018704484	-0.006633238
## C10_16_1	0.054739582	-0.076688317	0.009127963
## Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4	
## C12_2_2	0.003548871	-0.011174662	0.034593326
## chr1.2.1	-0.044498765	0.004742585	-0.018361427
## C3_5_1	0.015833268	-0.041094063	0.006421194
## chr8.80.1	-0.011797795	0.019787162	-0.046037954
## C10_16_1	0.014125342	-0.018780801	0.028197990
## Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1	
## C12_2_2	0.021925664	-0.05715982	-0.002136728
## chr1.2.1	0.008505291	-0.03846526	0.095737265
## C3_5_1	0.026365141	-0.03133071	-0.032358272
## chr8.80.1	-0.063288560	0.10257977	0.016166768
## C10_16_1	0.074527234	-0.03576619	0.002146108
## Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2	
## C12_2_2	0.023203254	-0.111879691	0.006610206
## chr1.2.1	-0.005381315	0.021804952	-0.017544695
## C3_5_1	0.038923067	-0.047644838	-0.003780970
## chr8.80.1	0.004933664	0.004591823	-0.001848924
## C10_16_1	-0.191086001	0.041213850	0.013028563
## Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3	
## C12_2_2	0.012279313	-0.05327088	0.17282136
## chr1.2.1	0.009440546	-0.01606142	-0.06669331
## C3_5_1	-0.006342669	0.01483305	-0.02947384
## chr8.80.1	-0.173663715	0.07155117	-0.01207588
## C10_16_1	-0.008097468	0.02383272	0.01284680
## Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3	
## C12_2_2	-0.011792072	0.008876157	0.001468720
## chr1.2.1	0.008799005	-0.003145704	0.019248806
## C3_5_1	0.015567351	-0.002575375	0.080047151
## chr8.80.1	0.001632778	0.025643859	-0.022498140
## C10_16_1	-0.025302115	-0.032416857	0.007708264
## Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4	
## C12_2_2	0.006698496	-0.003855412	-0.003697712
## chr1.2.1	-0.028875331	0.008488710	-0.001441199
## C3_5_1	-0.020704749	0.018827318	-0.006204741

## chr8.80.1	-0.092524188	-0.037956429	0.039764465
## C10_16_1	0.015427666	-0.006108046	-0.048947504
##	Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1
## C12_2_2	-0.016044813	0.004977911	0.005999077
## chr1.2.1	-0.013520243	0.014922081	-0.031482436
## C3_5_1	-0.026006759	-0.040020855	-0.039132799
## chr8.80.1	0.002707505	-0.030917693	0.011274455
## C10_16_1	0.004927675	-0.025372343	-0.054282791
##	Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2
## C12_2_2	0.045283974	0.0138265743	-0.029546036
## chr1.2.1	-0.013578334	0.0001584592	-0.003746103
## C3_5_1	0.043207232	-0.0193073276	0.029278142
## chr8.80.1	-0.006231426	0.0310465000	-0.018328254
## C10_16_1	-0.006546051	-0.0142858631	-0.033453675
##	Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2
## C12_2_2	0.004888716	-0.076707670	0.009015878
## chr1.2.1	0.012498492	-0.020172511	0.024414410
## C3_5_1	-0.002350421	-0.007346759	-0.053283260
## chr8.80.1	-0.037222022	0.029262918	-0.013066298
## C10_16_1	0.005960636	0.052336575	-0.055730222
##	Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3
## C12_2_2	-0.029226255	-0.001299955	0.080249284
## chr1.2.1	-0.008004538	0.020884843	0.021723781
## C3_5_1	0.006644797	-0.010733121	0.034384009
## chr8.80.1	0.097502215	0.018844207	0.013138469
## C10_16_1	-0.006968723	0.070218901	0.001509933
##	Desiree.4+Electra.3	Desiree.1+Electra.4	Desiree.2+Electra.4
## C12_2_2	0.02486272	-0.003538552	-0.017093774
## chr1.2.1	0.01261185	-0.044860023	0.031375371
## C3_5_1	0.05021098	0.105635325	-0.065842839
## chr8.80.1	-0.01603568	0.035151135	-0.005497951
## C10_16_1	0.05259808	-0.025569016	-0.002324899
##	Desiree.3+Electra.4	Desiree.4+Electra.4	
## C12_2_2	0.055673592	-0.044184595	
## chr1.2.1	0.006870230	-0.005413092	
## C3_5_1	-0.003690727	0.011520550	
## chr8.80.1	-0.029856070	-0.009890610	
## C10_16_1	-0.004005309	0.323793830	
##			
## , , Lower.CI			
##			
##	Desiree.1+Desiree.2	Desiree.1+Desiree.3	Desiree.1+Desiree.4
## C12_2_2	-0.23396073	-0.16918945	-0.03246549
## chr1.2.1	-0.25648212	-0.15167239	-0.29849712
## C3_5_1	-0.17847476	-0.05808595	-0.23142630
## chr8.80.1	-0.13420817	-0.19025543	-0.16099678
## C10_16_1	-0.03798353	-0.05877338	-0.02391057
##	Desiree.2+Desiree.3	Desiree.2+Desiree.4	Desiree.3+Desiree.4
## C12_2_2	-0.12411418	-0.20531961	-0.12606127
## chr1.2.1	-0.08080385	-0.10346198	-0.12173536
## C3_5_1	-0.29785730	-0.03452728	-0.08590445
## chr8.80.1	-0.09256777	-0.15050546	-0.02871298
## C10_16_1	-0.12727426	-0.08414436	-0.18255553
##	Electra.1+Electra.2	Electra.1+Electra.3	Electra.1+Electra.4

## C12_2_2	-0.1224696	-0.14236814	-0.2183844
## chr1.2.1	-0.0651289	-0.24155668	-0.4160522
## C3_5_1	-0.2162889	-0.20706766	-0.1323709
## chr8.80.1	-0.2221240	-0.06817257	-0.1543488
## C10_16_1	-0.3003802	-0.19196205	-0.1822956
## Electra.2+Electra.3	Electra.2+Electra.4	Electra.3+Electra.4	
## C12_2_2	-0.09460226	-0.1920684	-0.14853585
## chr1.2.1	-0.24641324	-0.1248619	-0.05661107
## C3_5_1	-0.07020666	-0.2430915	-0.12243887
## chr8.80.1	-0.12670735	-0.1483153	-0.13752583
## C10_16_1	-0.05399023	-0.1148565	-0.12115178
## Picasso.1+Picasso.2	Picasso.1+Picasso.3	Picasso.1+Picasso.4	
## C12_2_2	-0.24637348	-0.17039299	-0.1349081
## chr1.2.1	-0.13208347	-0.24773690	-0.1192212
## C3_5_1	-0.14877685	-0.16434260	-0.1197129
## chr8.80.1	-0.15648629	-0.06910276	-0.1367929
## C10_16_1	-0.04563464	-0.32905827	-0.1150442
## Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4	
## C12_2_2	-0.16522020	-0.20623999	-0.10030445
## chr1.2.1	-0.30001780	-0.13529937	-0.21998847
## C3_5_1	-0.09809175	-0.26344888	-0.12933352
## chr8.80.1	-0.15577119	-0.07451691	-0.24527186
## C10_16_1	-0.17669401	-0.20464841	-0.08094517
## Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1	
## C12_2_2	-0.10929055	-0.31014035	-0.15730838
## chr1.2.1	-0.11590654	-0.26387891	-0.02817091
## C3_5_1	-0.06173780	-0.21927853	-0.22101651
## chr8.80.1	-0.27508839	-0.01473152	-0.04148229
## C10_16_1	-0.02122438	-0.21559122	-0.10239775
## Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2	
## C12_2_2	-0.08259932	-0.42460727	-0.14478886
## chr1.2.1	-0.16054235	-0.08187151	-0.19440681
## C3_5_1	-0.04247569	-0.25818947	-0.13145524
## chr8.80.1	-0.08122548	-0.09242779	-0.11008198
## C10_16_1	-0.39898529	-0.04639667	-0.08354124
## Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3	
## C12_2_2	-0.1366850	-0.30246512	-0.0179543
## chr1.2.1	-0.1163609	-0.18887458	-0.3298088
## C3_5_1	-0.1384896	-0.08590038	-0.2140481
## chr8.80.1	-0.3814207	-0.01987696	-0.1464328
## C10_16_1	-0.1498538	-0.06260728	-0.0842533
## Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3	
## C12_2_2	-0.18402629	-0.13785427	-0.14691133
## chr1.2.1	-0.11588739	-0.15783900	-0.08481186
## C3_5_1	-0.08099035	-0.12800948	-0.02548408
## chr8.80.1	-0.08890969	-0.03211485	-0.17266056
## C10_16_1	-0.20341324	-0.21970435	-0.09439423
## Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4	
## C12_2_2	-0.13247018	-0.16438140	-0.18103926
## chr1.2.1	-0.23426367	-0.11745991	-0.14476253
## C3_5_1	-0.19492055	-0.07732192	-0.14438164
## chr8.80.1	-0.31731395	-0.21584413	-0.02697008
## C10_16_1	-0.05780683	-0.12291245	-0.24205512
## Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1	

## C12_2_2	-0.20025332	-0.1372915	-0.12431230
## chr1.2.1	-0.17028816	-0.1147087	-0.25611125
## C3_5_1	-0.20912884	-0.2522933	-0.25100043
## chr8.80.1	-0.09252297	-0.2269988	-0.09619855
## C10_16_1	-0.07842491	-0.2192422	-0.27857062
##	Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2
## C12_2_2	-0.07317104	-0.11622569	-0.24396599
## chr1.2.1	-0.19676453	-0.16303625	-0.16061408
## C3_5_1	-0.05337355	-0.19716687	-0.06751871
## chr8.80.1	-0.13916535	-0.05065674	-0.18230911
## C10_16_1	-0.16053987	-0.18210475	-0.23227800
##	Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2
## C12_2_2	-0.1460613	-0.37740739	-0.11004354
## chr1.2.1	-0.1135773	-0.21721421	-0.09529894
## C3_5_1	-0.1484098	-0.16161041	-0.29051273
## chr8.80.1	-0.2329457	-0.04120073	-0.15682765
## C10_16_1	-0.1006508	-0.03407757	-0.28387714
##	Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3
## C12_2_2	-0.24030263	-0.16027668	-0.04424253
## chr1.2.1	-0.18149207	-0.11727670	-0.10718075
## C3_5_1	-0.12271976	-0.17333679	-0.06807266
## chr8.80.1	-0.02001919	-0.07842786	-0.08835606
## C10_16_1	-0.16386382	-0.03312457	-0.15177439
##	Desiree.4+Electra.3	Desiree.1+Electra.4	Desiree.2+Electra.4
## C12_2_2	-0.07914536	-0.16565565	-0.22231838
## chr1.2.1	-0.13359375	-0.29281966	-0.08892488
## C3_5_1	-0.04218647	-0.02251045	-0.31846896
## chr8.80.1	-0.17522677	-0.05415865	-0.14488913
## C10_16_1	-0.04210120	-0.21439514	-0.13619131
##	Desiree.3+Electra.4	Desiree.4+Electra.4	
## C12_2_2	-0.06410074	-0.276011181	
## chr1.2.1	-0.14012308	-0.180138823	
## C3_5_1	-0.15156443	-0.107873955	
## chr8.80.1	-0.21425932	-0.156784005	
## C10_16_1	-0.15587577	0.006033297	
##			
## , , Upper.CI			
##			
##	Desiree.1+Desiree.2	Desiree.1+Desiree.3	Desiree.1+Desiree.4
## C12_2_2	0.08909697	0.15634397	0.37304772
## chr1.2.1	0.06584486	0.14148582	0.05594632
## C3_5_1	0.09496252	0.24500052	0.06906395
## chr8.80.1	0.09647625	0.03954005	0.06255885
## C10_16_1	0.20917336	0.18390826	0.29951328
##	Desiree.2+Desiree.3	Desiree.2+Desiree.4	Desiree.3+Desiree.4
## C12_2_2	0.20613171	0.10705141	0.21363882
## chr1.2.1	0.25007848	0.19146202	0.19234899
## C3_5_1	0.03746417	0.31651796	0.19103387
## chr8.80.1	0.11732471	0.07706606	0.22553352
## C10_16_1	0.10365238	0.12918124	0.05347166
##	Electra.1+Electra.2	Electra.1+Electra.3	Electra.1+Electra.4
## C12_2_2	0.22105920	0.1906842	0.14559500
## chr1.2.1	0.33255138	0.1247711	0.04108218
## C3_5_1	0.10731351	0.1136097	0.17789215

## chr8.80.1	0.07043560	0.2730970	0.11992542
## C10_16_1	0.05835306	0.1681981	0.14711359
## Electra.2+Electra.3	Electra.2+Electra.4	Electra.3+Electra.4	
## C12_2_2	0.3062283	0.15138507	0.1964685
## chr1.2.1	0.1155259	0.23371834	0.3816853
## C3_5_1	0.2816561	0.09898103	0.2051375
## chr8.80.1	0.1453335	0.14072204	0.1402992
## C10_16_1	0.3317129	0.24289299	0.2339027
## Picasso.1+Picasso.2	Picasso.1+Picasso.3	Picasso.1+Picasso.4	
## C12_2_2	0.11528185	0.20208838	0.22994523
## chr1.2.1	0.20220410	0.09208580	0.20902981
## C3_5_1	0.13697614	0.13451817	0.15717242
## chr8.80.1	0.08576729	0.17873399	0.09490345
## C10_16_1	0.28920188	0.03074301	0.17213621
## Picasso.2+Picasso.3	Picasso.2+Picasso.4	Picasso.3+Picasso.4	
## C12_2_2	0.18832353	0.14663147	0.27827773
## chr1.2.1	0.06736223	0.16704629	0.11961234
## C3_5_1	0.19160486	0.06216396	0.16982945
## chr8.80.1	0.08485603	0.18986940	0.02914674
## C10_16_1	0.24745473	0.10506455	0.23161223
## Desiree.1+Picasso.1	Desiree.2+Picasso.1	Desiree.3+Picasso.1	
## C12_2_2	0.23069834	0.04214358	0.14503866
## chr1.2.1	0.17203935	0.05857601	0.39188453
## C3_5_1	0.20524952	0.05070644	0.05208887
## chr8.80.1	0.02141247	0.32047956	0.14487472
## C10_16_1	0.28176732	0.03596313	0.11749114
## Desiree.4+Picasso.1	Desiree.1+Picasso.2	Desiree.2+Picasso.2	
## C12_2_2	0.213452331	0.02693587	0.18138743
## chr1.2.1	0.131533282	0.21739947	0.09153766
## C3_5_1	0.239294003	0.03539845	0.11073202
## chr8.80.1	0.113012690	0.12156959	0.09796554
## C10_16_1	0.004279343	0.25254304	0.16295646
## Desiree.3+Picasso.2	Desiree.4+Picasso.2	Desiree.1+Picasso.3	
## C12_2_2	0.203866755	0.04892628	0.50685169
## chr1.2.1	0.178715225	0.09406921	0.03441800
## C3_5_1	0.103512443	0.17338582	0.05397227
## chr8.80.1	0.006147014	0.28331126	0.07070689
## C10_16_1	0.103978974	0.19963541	0.16264386
## Desiree.2+Picasso.3	Desiree.3+Picasso.3	Desiree.4+Picasso.3	
## C12_2_2	0.11358384	0.18788445	0.1551553
## chr1.2.1	0.17394800	0.14154270	0.2056622
## C3_5_1	0.17657300	0.11627511	0.3280711
## chr8.80.1	0.09962248	0.17859475	0.0394525
## C10_16_1	0.06637305	0.05320071	0.1448587
## Desiree.1+Picasso.4	Desiree.2+Picasso.4	Desiree.3+Picasso.4	
## C12_2_2	0.17394538	0.14275653	0.15958558
## chr1.2.1	0.06733866	0.17425227	0.14027089
## C3_5_1	0.07657324	0.18778311	0.11018167
## chr8.80.1	0.01768034	0.02870004	0.22465306
## C10_16_1	0.15559952	0.08534312	0.02906648
## Desiree.4+Picasso.4	Desiree.1+Electra.1	Desiree.2+Electra.1	
## C12_2_2	0.10475198	0.17011977	0.15954360
## chr1.2.1	0.08880786	0.20977963	0.08848469
## C3_5_1	0.07028825	0.05288201	0.05892205

## chr8.80.1	0.10787036	0.05762174	0.16340947
## C10_16_1	0.11498820	0.08593280	0.03502151
##	Desiree.3+Electra.1	Desiree.4+Electra.1	Desiree.1+Electra.2
## C12_2_2	0.30265457	0.19873610	0.08496583
## chr1.2.1	0.11954562	0.16733819	0.14066812
## C3_5_1	0.26957324	0.09383286	0.22767200
## chr8.80.1	0.09728006	0.21713060	0.07266679
## C10_16_1	0.12431664	0.09865346	0.05879343
##	Desiree.2+Electra.2	Desiree.3+Electra.2	Desiree.4+Electra.2
## C12_2_2	0.17855531	0.04499291	0.16839794
## chr1.2.1	0.19341986	0.09986020	0.23573896
## C3_5_1	0.13940199	0.12214344	0.04299469
## chr8.80.1	0.04242467	0.20564863	0.07618720
## C10_16_1	0.14058939	0.27932162	0.03410659
##	Desiree.1+Electra.3	Desiree.2+Electra.3	Desiree.3+Electra.3
## C12_2_2	0.08064555	0.1511330	0.3930176
## chr1.2.1	0.13543395	0.2340921	0.2323943
## C3_5_1	0.16360537	0.1141710	0.2444672
## chr8.80.1	0.35388218	0.1861196	0.1633524
## C10_16_1	0.12458996	0.3144579	0.1618873
##	Desiree.4+Electra.3	Desiree.1+Electra.4	Desiree.2+Electra.4
## C12_2_2	0.21871034	0.14565478	0.12609509
## chr1.2.1	0.21183610	0.06282612	0.26185561
## C3_5_1	0.27916251	0.38330553	0.03259444
## chr8.80.1	0.07649231	0.23635143	0.11012921
## C10_16_1	0.28447040	0.07728453	0.12663345
##	Desiree.3+Electra.4	Desiree.4+Electra.4	
## C12_2_2	0.32556885	0.05466334	
## chr1.2.1	0.18428331	0.14756837	
## C3_5_1	0.13322205	0.17640118	
## chr8.80.1	0.04998716	0.09573091	
## C10_16_1	0.13610125	0.60917493	

No additive effect of any single parental haplotype at any QTL is significantly different than zero at alpha 0.1. However, the diplotype Desiree.4+Electra.4 has an effect significantly different than zero at alpha 0.1.

```

colors_y <- c("black","black","black","black","black", "green4", "black"
, "darkorange2", "black", "black","darkorange2", "green4")
colors_x <- c("black","black","black","black","black", "green4", "black"
, "darkorange2", "black", "black","darkorange2", "green4")
new_full_model$plots$C10_16_1$digenic@theme$axis.text.y@colour <- colors_y
new_full_model$plots$C10_16_1$digenic@theme$axis.text.x@colour <- colors_x

p3_dom <- new_full_model$plots$C10_16_1$digenic

p3_dom$labels$title <- "Trait: Common Scab"

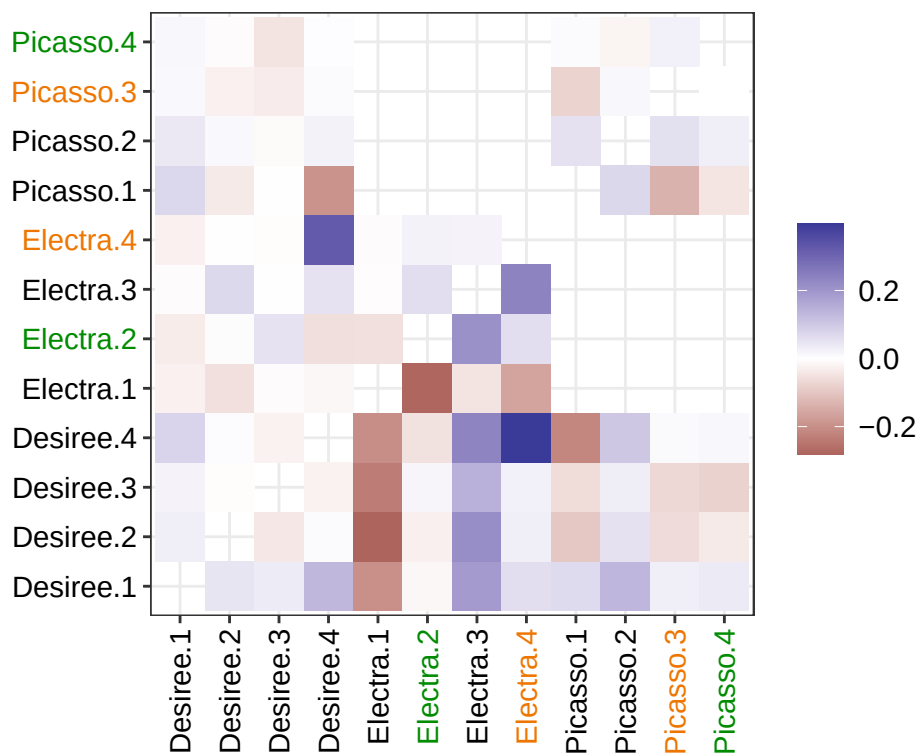
p3_dom$labels$subtitle <- "QTL: Chr10@57 Mb"

p3_dom <- p3_dom + theme(text = element_text(size = 14)) + labs(title = NULL)

p3_dom

```

QTL: Chr10@57 Mb



```
ggsave("Figure4.png",device="png",dpi=600,height=5,width=5.5)
```