

**Figure S1: Primer sequence**

Primer name	Primer sequence ( 5'-3' )	Primer function
<i>sox11a</i> -g1-F	TGTAATACGACTCACTATA ggtcgctttatgtgccgg GTTTTAGAGCTAGAAAT	gRNA synthesis
<i>sox11a</i> -g2-F	TGTAATACGACTCACTATA ggctgtcttcaccagtct GTTTTAGAGCTAGAAAT	
<i>sox11b</i> -g1-F	TGTAATACGACTCACTATA gggtcgtttgatgtggccgg GTTTTAGAGCTAGAAAT	
<i>sox11b</i> -g2-F	TGTAATACGACTCACTATA gggtcgtttgatgtggccgg GTTTTAGAGCTAGAAAT	
gRNA-R	AAAAAAAGCACCGACTCGGTGCCAC	
<i>sox11a</i> -F	ACTTCGCCTCCTCCGCGCAA	real-time PCR
<i>sox11a</i> -R	AGCCCAGGCTGCCCTCGCTA	
<i>sox11b</i> -F	ATGGCTGACTACCCCGACT	
<i>sox11b</i> -R	GCTGCTTTGACACTTTTGC	
<i>p2rx4b</i> -F	CTTTGGAATCCGCTTTGACG	
<i>p2rx4b</i> -R	AGGTTAAGAAGGGCAAGAGC	
<i>calhm2</i> -F	GTGATTGAACGCCAGCTACA	
<i>calhm2</i> -R	TATGCCTCCTGCTGATAGCC	
<i>mctp2b</i> -F	CTCCAGAGTGCCCTCAGATA	
<i>mctp2b</i> -R	GCACCTTCACACAGACTGAT	
<i>rcn3</i> -F	ATAATGAAGCCCGGCATCTC	
<i>rcn3</i> -R	TTTGGTGAGATCCTCTCCGT	
<i>s100a11</i> -F	ACAAGCTTGGTCAAATCCCA	
<i>s100a11</i> -R	AGAACTCCATGAACGTCAGC	
<i>chrm2a</i> -F	TGAACGCCAGCTACAGTATG	
<i>chrm2a</i> -R	TCCTGCTGATAGCCAAGAGT	
<i>slc8a4a</i> -F	AAGAAGAGGTGGCCAAGATG	
<i>slc8a4a</i> -R	CAGCGCAAGGTTAGTCTTCT	
<i>aldh7a1</i> -F	GAAGAGTGTTCCGCTGGTTA	
<i>aldh7a1</i> -R	CAAACGCTCCTCCAATCTCA	
<i>matn1</i> -F	TTGCCAAGAAGCTGCAAATC	
<i>matn1</i> -R	CTCTTCGTCACAGCTTCCAA	
<i>and1</i> -F	CTGATCCGCAACAGGAGAAA	
<i>and1</i> -R	CTCTGCAACTCCGTCTTTGT	
<i>crtap</i> -F	AAATTTGGCCTCGACGATGA	
<i>crtap</i> -R	GGCATGAACTTCTGTTTGGC	
<i>dlx4a</i> -F	ATCCAGGAGCTTACCTACCC	

<i>dlx4a</i> -R	CGTTCAGCCGTATTTCTCCA		
<i>twist1a</i> -F	GTCAACATCCCCTAACGCA		
<i>twist1a</i> -R	CTCCTTCCAGTGAGTTCAGC		
<i>twist1b</i> -F	TTCTCGGTTTGGAGGATGGA		
<i>twist1b</i> -R	AGCTCACGGTTTGACCATTT		
<i>sec23a</i> -F	CCCGAGTATGAGAACTCCG		
<i>sec23a</i> -R	CGTGCTCAGTGTCGATGTAG		
<i>osc</i> -F	ATCAGCTGACACAGAAGCGA		
<i>osc</i> -R	GGCGGTGATGATTCCAGACG		
<i>runx2a</i> -F	GACCATGGTGGAGATCATAGC		
<i>runx2a</i> -R	GGGTTCGTGAATACTGTGATTG		
<i>runx2b</i> -F	AGAGCTTCACCCTGACGATTAC		
<i>runx2b</i> -R	AGGTACGATGGGTATGTCTGGT		
<i>ctsk</i> -F	GTAACGAGAGGGCACTGAC		
<i>ctsk</i> -R	TTCCTTGTTGCAGTTTGGGT		
<i>entpd5a</i> -F	TGAAGAGTGGAGCTTTGGTG		
<i>entpd5a</i> -R	GATGCTGCTTCCCTTGACCT		
<i>coll1a1a</i> -F	TCTGCTGGATCAGCTGGTAA		
<i>coll1a1a</i> -R	CAATTTCTCCATTGCGACCAC		
<i>akt2</i> -F	AAGAAGCTCGTTCACCCTT		
<i>akt2</i> -R	GGTCTGTGCAGTGAATCAT		
<i>atp6v1h</i> -F	CAGGTTATTGCCGTCGCA		
<i>atp6v1h</i> -R	TGTTTACCACCCAGCTGTTC		
$\beta$ -actin-F	ATGCCCTCGTGCTGTTTTC		
$\beta$ -actin-R	GCCTCATCTCCACATAGGA		
Probe- <i>and1</i> -F	GATGTACCTGCAGCACCTTG		Probe synthesis
Probe- <i>and1</i> -R	TAATACGACTCACTATAGGG CATACCCGACGAAACATTCA		
Probe- <i>crtap</i> -F	CTTTTCCGTTTGCGTCC		
Probe- <i>crtap</i> -R	TAATACGACTCACTATAGGG ACTGCGTTCTTCAGGTCATT		
Probe- <i>sec23a</i> -F	ACCAGCCTGCTGAGCTACTT		
Probe- <i>sec23a</i> -R	TAATACGACTCACTATAGGG TCCCTGCTAATGCCATTTTA		
Probe- <i>coll10a1a</i> -F	ACCAGCCTTACTCCGTGAAA		
Probe- <i>coll10a1a</i> -R	TAATACGACTCACTATAGGG TCCAGGTTTCCCTGAAGGTC		
<i>sox11a</i> -HMRA-F1	TGATGAAAGCGAATTCATGG	Genotyping	
<i>sox11a</i> -HMRA-R1	CTGGAGACTGTTCCATGATC		
<i>sox11b</i> -HMRA-F1	CGAGGAGAGCGAAATGATGGCTTG		
<i>sox11b</i> -HMRA-R1	CGCATTTCATGGGTCGTTTGATGTG		

**Figure S2: The conservation of *sox11* in various species.**

zb sox11a	QTDNS	TD.SMS	EAT	SD	S	F	VS.....	IN	T	82										
zb sox11b	QTDHS	TESSVS	EIT	TE	S	M	ACSPVP...	PK	T	87										
medaka sox11a	HMDNS	TDGMS	EAT	TE	S	F	ACSPVA...	IN	T	87										
rat sox11	QAESS	AESNLP	DAL	TE	G	F	ACSPVALDESD		S	90										
mice sox11	QAESS	AESNLP	DAL	TE	G	F	ACSPVALDESD		S	90										
human sox11	QAESL	AESNLP	EAL	TE	G	F	ACSPVALDESD		S	90										
zb sox11a			K		K	L	SSS	PSAP.	E	CSKT.....	S	S....	S	P	L	ANKTGSKSS	155			
zb sox11b			Q		K	L	SSS	PAVQ.	E	ISKS.....	V	AAA..	G	A	L	PSKPGNITA	162			
medaka sox11a			K		K	L	AS.	SSAP.	E	CAKL.....	A	TP...	S	S	M	K..	SGSKS.	157		
rat sox11			K		R	T	PAA	PSAGQ	D	SAAG.....	A	AAKGFG		A	L	APAG...KA	165			
mice sox11			K		R	T	PAA	PSAGQ	D	SAAG.....	A	AAKGFG		A	L	APAG...KA	165			
human sox11			K		R	M	PSA	PSASQ	E	SAAGGGGSAGGGAGGA		TSKGSS		G	L	APAAAGAKA	180			
zb sox11a	...	SHGYGDEYAFK.....	ST	VSKTVHIKSEFTDEDD	DSEEDSRVVRVKEEEDP.....	IRA	207													
zb sox11b	RASTQDCRFNVFT.....	NL	VTKS..	IKRELTDEDD	DDDDDDDEEDYEDE.....	EH	213													
medaka sox11a	...AHSYGDDCVFK.....	VA	T....	VKSELTDDED	DYEEDYRMGIKRAEEER.....	LRP	204													
rat sox11	GAGKAAQPGDCG.....	AG	AAKCVFLDDDDDEEDDE	ELQLRPKPDADDDDEPAHSHLLPPPAQQPPQLLR		235														
mice sox11	GAGKAAQPGDCA.....	AG	AAKCVFLDDDDDEEDDE	ELQLRPKPDADDDDEPAHSHLLPPPTQQPPQLLR		235														
human sox11	GAGKAAQSGDYGAGDDYVLGSLRVSGSGGGGAG	TVKCVFLDEDDDDDD	ELQLQIKQEPDEEDEEPPHQQLLPQPGQ..	PSQLLR		269														
zb sox11a	YNVAK	ST	E.	M	E	V	.....	NN	Y	NF	N.	ITKQSTMY...	S	.....	VSPASSRSV	T	S	SS	A	275
zb sox11b	IRLHN	AA	EH	M	E	S	HTSATH...	GS	F	NF	N.	ITKQSAAY...	S	.....	VSPASSFRSVS	S	S	SS	S	290
medaka sox11a	YNVAK	SA	E.	M	E	V	S.....	HN	F	NI	SKQSAASVS...	SSRSVSTSSSSSSSSSS	S	S	SG	A	282			
rat sox11	YSVAK	AA	PE	L	D	V	AGG.....		Y	SF	N.	ITKQPPP.AP	LSPASSRCVSTSSSS..	G	S	G	GA	A	313	
mice sox11	YSVAK	AA	PE	L	D	V	AGG.....		Y	SF	N.	ITKQPPP.AP	LSPASSRCVSTSSSS..	G	S	G	GA	A	313	
human sox11	YNVAK	SA	PE	L	D	V	AGATSGAGGGS		Y	SF	N.	ITKQHPPLAQ	LSPASSRSVSTSSSSSSG	S	G	SG	A	358		
zb sox11a	LF	F	FASSAQSS...E	SQ.NP	S	E	E	353												
zb sox11b	LV	F	LAAGSHTA...D	.N.TS	C	D	D	367												
medaka sox11a	LF	F	FAPSAPGS...E	...NS	S	D	D	358												
rat sox11	MF	L	FSQGAHSACEQP	AG.AA	S	D	D	394												
mice sox11	MF	L	FSQGAHSACEQP	AG.AA	S	D	D	394												
human sox11	MF	L	FSQSAHSASEQQ	GGAAA	S	D	D	440												

**Figure S3: The second line of *sox11a*<sup>m/m</sup> mutant and *sox11b*<sup>m/m</sup> mutant**

A: The target site of *sox11a*<sup>m/m</sup> mutant line.

CTCGATAAACCCAGACTGGTGCAAGACAGCCACCGGACACATA  
 CTCGATAAACCCAGAC-----AGCCACCGGACACATA -11bp

B: The amino sequence of Sox11a

MVQQTDNSETDSMSREATDSDESEFMVSINPDWCKTAT  
 GHIKRPMNAFMVWSKIERRKIMEQSPDMHNAEISKRLG  
 KRWKMLKDSEKIPFIREAERLRLKHMADYPDYKYRPPK  
 KPKLDSSSKPSAPSPEKCSKTSKSSKKCPKLKANKTGSK  
 SSSHGYGDEYAFKSTKVSKTVHIKSEFTDEDDDDSEED  
 SRVVRVKEEEDPIRAYNVAKVPASPTLSSSTESEGASMYE  
 EVRNNRLYYNFNITKQSTMYPASVSPASSRSVSTSSSS  
 EDADDLLFDFSLNFASSAQSSSELGSQNPGNLSLSLVDKE  
 LESFSEGLGSHFEPDYCTPELSEMIAGDWLEANFSDLV  
 FTY\*

C: A frameshift mutation of *sox11a*<sup>m/m</sup> mutant

MVQQTDNSETDSMSREATDSDESEFMVSINPD SHRTHK  
 ATDERVHGVV\*

D: The target site of *sox11b*<sup>m/m</sup> mutant line.

GGTGCCACCGAAACCGACTGGTGCAAGACAGCCACCGGCCACAT  
GGTGCCACCGAAACCG--ACTGGTGCAAGACAGCCACCGGCCACAT -1bp

E: The amino sequence of Sox11b

MVQQTDHSETESSVSRETTDTEESEMMACSPVPPKPDW  
CKTATGHIKRPMNAFMetVWSKIERRKIMEQSPDMHNAEI  
SKRLGKRWKMLKDSEKIPFIREAERLRLQHMADYPDYK  
YRPKKKPKLDSSSKPAVQSPEKISKSVKAAAGKKCAKPK  
PSKPGNITARASTQDCRFNYVFTNLKVTKSIKRELTDDDE  
DDDDDDDDDDDEEDDYEDEEHIRLHNVPASPTLSSAAES  
EHGASMYEESRHTSATHGSRLFYNFKNITKQSAAYPASV  
SPASSFRSVSSSSSSSSSEDSDDLLVDFSLNLAAGSHTADL  
GNTSGNLCLSLVDKDLDSFSEGLGSHFEPDYCTPELS  
EMIAGDWLEANFSDLVFTY\*

F: A frameshift mutation of *sox11b*<sup>m/m</sup> mutant

MVQQTDHSETESSVSRETTDTEESEMMACSPVPPKPTGA  
RQPPATSNDP\*

Figure S4: The production process of *sox11a*<sup>m/m</sup>*sox11b*<sup>m/m</sup> double mutant.

<i>sox11a</i> <sup>+/+</sup> <i>sox11b</i> <sup>+/+</sup>	<i>sox11a</i> <sup>+/+</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>+/+</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/+</sup>
<i>sox11a</i> <sup>+/+</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>+/+</sup> <i>sox11b</i> <sup>m/m</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/m</sup>
<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>+/+</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>m/m</sup> <i>sox11b</i> <sup>+/+</sup>	<i>sox11a</i> <sup>m/m</sup> <i>sox11b</i> <sup>m/+</sup>
<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>m/+</sup> <i>sox11b</i> <sup>m/m</sup>	<i>sox11a</i> <sup>m/m</sup> <i>sox11b</i> <sup>m/+</sup>	<i>sox11a</i> <sup>m/m</sup> <i>sox11b</i> <sup>m/m</sup>

Figure S5: The ratio of *sox11a*<sup>m/m</sup> mutant with curved spine (\*\*\*\**P*<0.0001).

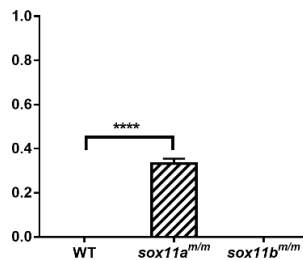
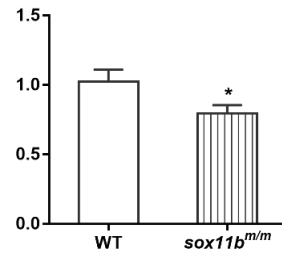


Figure S6: The expression level of *sox11a* in WT and *sox11b*<sup>m/m</sup> mutant (\**P*<0.05).



**Figure S7: The expression level of *sox11b* in WT and *sox11a<sup>m/m</sup>* mutant (\*\* $P < 0.01$ ).**

