Supplementary File 1

Tukey HSD post-hoc comparisons of least squares mean vaginal pH values across groups and time points.

Group; Time					Least squares means
L; T=0	A				6.5172157
L; T=30	A	B			6.4108327
L; T=60	A	B			6.3044497
L; T=90	A	B	C		6.1980667
P+L; T=0	A	B	C	D	5.6519459
P+L; T=30		B	C	D	5.3662316
P+L; T=90			C	D	5.1757554
P+L; T=60				D	5.1281364

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 2

p-values for the fixed effects (Group, Time and Group × Time) from the linear mixed-effects model applied to log-transformed vaginal pH values.

	Log-transformed value	p-value
Group	4.380	0.00004
Time	0.768	0.17076
Group x Time	0.049	0.89380

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 3

Parameter estimates from the linear mixed-effects model applied to log-transformed vaginal pH

	Estimate	Standard error	95% CI	Denominator Degrees of Freedom	t-ratio	Two-sided p-value
Intercept	6.7045963	0.179959	6.352 to 7.057	199.2	37.26	<0.0001
Group (Laser)	0.51135619	0.122835	0.271 to 0.752	224	4.18	<0.0001
T=0	0.2405015	0.122351	0.001 to 0.480	263	1.97	0.0504
T=30	0.0444529	0.122351	−0.195 to 0.284	263	0.36	0.7167
T=60	-0.127786	0.122351	−0.368 to 0.112	263	-1.04	0.2972
Laser x T=0	-0.080927	0.122351	−0.321 to 0.159	263	-0.66	0.5089
Laser x T=30	0.0087386	0.122351	−0.231 to 0.249	263	0.07	0.9431
Laser x T=60	0.0745947	0.122351	−0.165 to 0.314	263	0.61	0.5426

Parameter estimates from the linear mixed-effects model applied to log-transformed vaginal pH. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels. Approximate 95% confidence intervals are also provided to facilitate interpretation of effect magnitude and precision.

Supplementary File 4

Tukey HSD post-hoc comparisons of least squares mean dyspareunia VAS scores (0–10) across groups and time points.

Group; Time							Least squares means
L; T=0	A						8.0425532
P+L; T=0	A	B					7.5714286
L; T=30		B	C				6.7872340
L; T=60				D			5.8297872
P+L; T=30			C	D	E		5.5714286
L; T=90					E	F	3.9787234
P+L; T=60						F	3.7142857
P+L; T=90						F	2.4761905

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 5

p-values for the fixed effects (time, group, and group × time) from the linear mixed-effects model applied to log-transformed dyspareunia VAS scores.

	Log-transformed value	p-value
Time	41.388	0.00000
Group	2.243	0.00572
Group x Time	1.708	0.01959

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 6

Dyspareunia Estimates and Statistical Tests From the Linear Mixed Model Applied to the Log-Transformed Variable

	Value	Standard error	Denominator Degrees of Freedom	T-ratio	Two-sided p-value for the t-test
Intercept	5.4964529	0.233125	66	23.68	<0.0001
Group (Laser)	0.6031206	0.233125	66	2.86	0.0057
T=0	2.310537	0.161006	198	14.35	<0.0001
T=30	0.2868774	0.161006	198	4.24	<0.0001
T=60	-0.724417	0.161006	198	-4.50	<0.0001
Laser x T=0	-0.427558	0.161006	198	-2.66	0.0086
Laser x T=30	-0.055218	0.161006	198	-0.34	0.7320
Laser x T=60	0.3946302	0.161006	198	2.45	0.0151

Parameter estimates and statistical tests from the linear mixed-effects model applied to the log-transformed dyspareunia VAS scores. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels.

Supplementary File 7

Tukey HSD post-hoc comparisons of least squares mean pain VAS scores (0–10) across groups and time points.

Group; Time									Least squares means
L; T=0	A	B							8.2765957
P+L; T=0	A		C						8.1428571
L; T=30			C	D					6.9787234
P+L; T=30		B		D	E				6.5714286
L; T=60					E	F			5.6595745
P+L; T=60						F	G		4.8571429
L; T=90							G	H	4.2978723
P+L; T=90								H	3.5238095

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 8

p-values for the fixed effects (Time, Group, and Group × Time) from the linear mixed-effects model applied to log-transformed pain VAS scores.

	Log-transformed value	p-value
Time	41.268	0.00000
Group	0.568	0.27030
Group x Time	0.310	0.48923

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 9

Pain Estimates and Statistical Tests From the Linear Mixed Model Applied to the Log-Transformed Variable

	Value	Standard error	Denominator Degrees of Freedom	T-ratio	Two-sided p-value for the t-test
Intercept	6.0385005	0.238097	66	25.36	<0.0001
Group (Laser)	0.264691	0.238097	66	1.11	0.2703
T=0	2.1712259	0.153546	198	14.14	<0.0001
T=30	0.7365755	0.153546	198	4.80	<0.0001
T=60	-0.780142	0.153546	198	-5.08	<0.0001
Laser x T=0	-0.197822	0.153546	198	-1.29	0.1991
Laser x T=30	-0.061044	0.153546	198	-0.40	0.6914
Laser x T=60	0.1365248	0.153546	198	0.89	0.2750

Parameter estimates and statistical tests from the linear mixed-effects model applied to the log-transformed pain VAS scores. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels.

Supplementary File 10

Tukey HSD post-hoc comparisons of least squares mean vaginal dryness VAS scores (0–10) across groups and time points.

Group; Time							Least squares means
L; T=0	A						7.8510638
P+L; T=0	A	B					7.6190476
L; T=30		B	C				6.7872340
L; T=60				D			5.7872340
P+L; T=30			C	D	E		5.2380952
L; T=90					E	F	4.3191489
P+L; T=60				D	E	F	4.0476190
P+L; T=90						F	3.0952381

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 11

p-values for the fixed effects (time, group, and group × time) from the linear mixed-effects model applied to log-transformed vaginal dryness VAS scores.

	Log-transformed value	p-value
Time	36.759	0.00000
Group	1.817	0.01525
Group x Time	1.686	0.02062

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 12

Vaginal dryness Estimates and Statistical Tests From the Linear Mixed Model Applied to the Log-Transformed Variable

	Value	Standard error	Denominator Degrees of Freedom	T-ratio	Two-sided p-value for the t-test
Intercept	5.5930851	0.250034	66	22.37	<0.0001
Group (Laser)	0.5930851	0.250034	66	2.37	0.0206
T=0	2.1419706	0.153936	198	13.91	<0.0001
T=30	0.4195795	0.153936	198	2.73	0.0070
T=60	-0.675659	0.153936	198	-4.39	<0.0001
Laser x T=0	-0.477077	0.153936	198	-3.10	0.0022
Laser x T=30	0.1814843	0.153936	198	1.18	0.2398
Laser x T=60	0.2767224	0.153936	198	1.80	0.0738

Parameter estimates and statistical tests from the linear mixed-effects model applied to the log-transformed vaginal dryness VAS scores. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels.

Supplementary File 13

Tukey HSD post-hoc comparisons of least squares mean vaginal itching VAS scores (0–10) across groups and time points.

Group; Time							Least squares means
L; T=0	A						4.7021277
L; T=30		B	C				3.0212766
P+L; T=0		B		D			2.9047619
L; T=60		B	C	D	E		2.5106383
L; T=90				D	E	F	1.7234043
P+L; T=30			C		E	F	1.4761905
P+L; T=60					E	F	1.1428571
P+L; T=90						F	0.5714286

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 14

p-values for the fixed effects (time, group, and group × time) from the linear mixed-effects model applied to log-transformed vaginal itching VAS scores.

	Log-transformed value	p-value
Time	17.704	0.00000
Group	2.952	0.00112
Group x Time	0.176	0.66644

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 15

Vaginal itching Estimates and Statistical Tests From the Linear Mixed Model Applied to the Log-Transformed Variable

	Value	Standard error	Denominator Degrees of Freedom	T-ratio	Two-sided p-value for the t-test
Intercept	2.2565856	0.214987	66	10.50	<0.0001
Group (Laser)	0.7327761	0.214987	66	3.41	0.0011
T=0	1.5468592	0.163609	198	9.45	<0.0001
T=30	-0.007852	0.163609	198	-0.05	0.9618
T=60	-0.429838	0.163609	198	-2.63	0.0093
Laser x T=0	0.1659068	0.163609	198	1.01	0.3118
Laser x T=30	0.039767	0.163609	198	0.24	0.8082
Laser x T=60	-0.048886	0.163609	198	-0.30	0.7654

Parameter estimates and statistical tests from the linear mixed-effects model applied to the log-transformed vaginal itching VAS scores. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels.

Supplementary File 16

Tukey HSD post-hoc comparisons of least squares mean vaginal burning VAS scores (0–10) across groups and time points.

Group; Time							Least squares means
L; T=0	A						5.8936170
P+L; T=0	A	B					5.2380952
L; T=30		B	C				4.1276596
L; T=60		B	C	D			3.8510638
P+L; T=30			C	D	E		3.0000000
L; T=90					E	F	2.4893617
P+L; T=60				D	E	F	2.0476190
P+L; T=90						F	1.2380952

Levels not connected by the same letter are significantly different. HSD: Honestly Significant Difference; L= laser; P=probiotic; T= time. Values of T are expressed as days.

Supplementary File 17

p-values for the fixed effects (Time, Group, and Group × Time) from the linear mixed-effects model applied to log-transformed vaginal burning VAS scores.

	Log-transformed value	p-value
Time	22.961	0.00000
Group	1.611	0.02448
Group x Time	0.469	0.33970

Log-transformed values indicate natural logarithm–transformed measurements.

Supplementary File 18

Vaginal burning Estimates and Statistical Tests From the Linear Mixed Model Applied to the Log-Transformed Variable

	Value	Standard error	Denominator Degrees of Freedom	T-ratio	Two-sided p-value for the t-test
Intercept	3.485689	0.262669	66	13.27	<0.0001
Group (Laser)	0.6047366	0.262669	66	2.30	0.0245
T=0	2.0801672	0.19258	198	10.80	<0.0001
T=30	0.0781408	0.19258	198	0.41	0.6854
T=60	-0.536348	0.19258	198	-2.79	0.0059
Laser x T=0	-0.276976	0.19258	198	-1.44	0.1519
Laser x T=30	-0.040907	0.19258	198	-0.21	0.8320
Laser x T=60	0.2969858	0.19258	198	1.54	0.1246

Parameter estimates and statistical tests from the linear mixed-effects model applied to the log-transformed vaginal burning VAS scores. The probiotic plus laser group and T=90 were specified as reference categories; therefore, reported coefficients represent differences relative to these reference levels.

Supplementary File 19

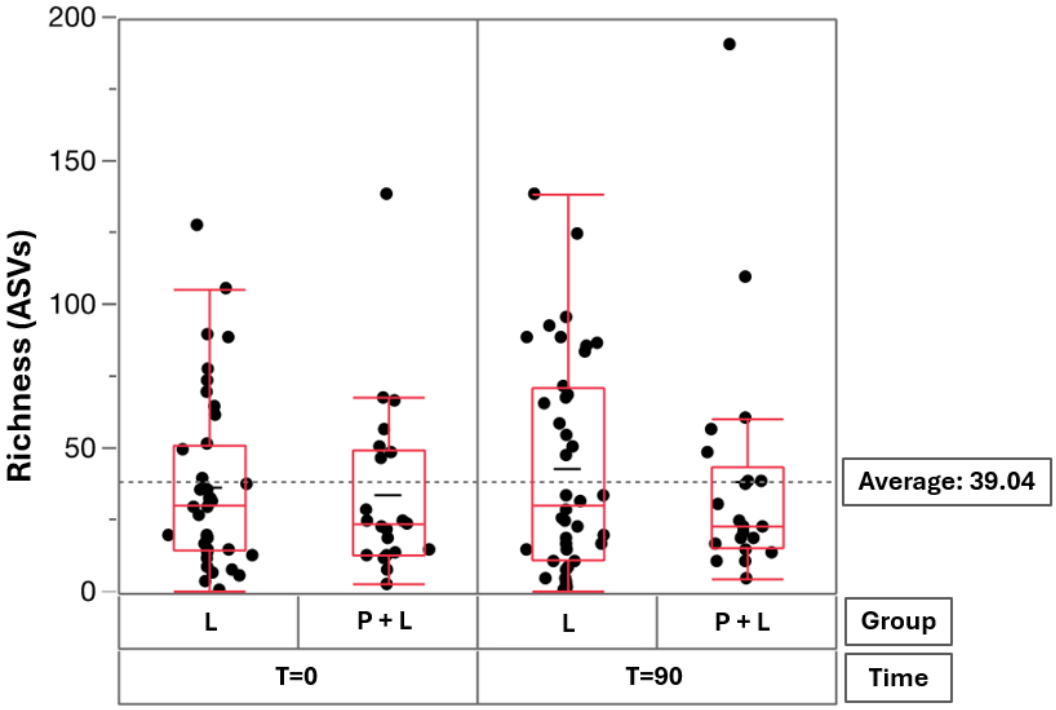
Patients' Global Expectation and Satisfaction Scores

Outcome	Group	N	Mean	SD	p-value
Patients' Global Expectation (PGE)	Laser	47	8.02	1.58	0.66
	Probiotic + Laser	21	7.81	1.89	
Patients' Global Satisfaction (PGS)	Laser	47	7.98	1.62	0.97
	Probiotic + Laser	21	8.00	1.95	

Data are expressed as Mean ± Standard Deviation. Between-group comparisons were performed using parametric and non-parametric tests, as appropriate. No statistically significant differences were observed between groups.

Supplementary File 20

Distribution of individual ASV values in both groups



AVS: Amplicon sequence variant; T=0: enrollment; T=90: end of the study.

Supplementary File 21

Descriptive statistics of vaginal microbiota richness (ASVs)

Group	Time	N	Mean	SD	Min	Max	Median	IQR
Laser	T=0	40	37.03	30.16	1	128	31.00	36.50
Laser	T=90	40	43.53	37.04	1	139	30.50	59.25
Probiotic + laser	T=0	21	34.43	30.84	3	139	24.00	36.50
Probiotic + laser	T=90	21	38.95	42.05	5	191	23.00	28.00

ASVs: amplicon sequence variants; IQR: Interquartile range; SD: Standard Deviation; Min: Minimum; Max; Maximum. Values are expressed using decimal points in accordance with international notation.

Supplementary File 22

***Lactobacillus* spp. quantitative summaries based on interquartile ranges**

Group	Time	N	*L. crispatus*	*L. gasseri*	*L. iners*	*L. jensenii*

Laser	T=0	40	0.363%	0.426%	2.758%	0.278%
Laser	T=90	40	0.282%	0.136%	2.026%	0.010%
Probiotic + laser	T=0	21	6.058%	0.025%	83.635%	0.041%
Probiotic + laser	T=90	21	13.783%	0.015%	17.900%	0.003%

Supplementary File 23

Mean relative abundance of additional *Lactobacillus* species

Taxon	Laser-only T=0 mean (%)	Laser-only T=90 mean (%)	Probiotic + Laser T=0 mean (%)	Probiotic + Laser T=90 mean (%)
L. animalis	0.0994	0.0532	0.0485	0.0848
L. salivarius	0.0226	0.0240	0.0313	0.0051
L. paracasei	0.1396	0.0550	0.1131	1.4998
L. rhamnosus	0.1895	0.0345	0.0091	0.0019
L. backii	0.0058	0.0022	0.0053	0.0254
L. heilongjiangensis	0.0000	0.0013	0.0000	0.0000
L. delbrueckii	0.0003	0.0005	0.0002	0.0001
L. oris	0.0000	0.0016	0.0000	0.0000
L. plantarum	0.0011	0.0029	0.0000	0.0011
L. fermentum	0.0144	0.0002	0.0045	0.0000

L. agilis	0.0039	0.0007	0.0001	0.0001
L. aviarius	0.0341	0.0001	0.0000	0.0010
L. acidophilus	0.0005	0.0000	0.0000	0.0003
L. reuteri	0.0298	0.0458	0.0060	0.0739
L. mucosae	0.0101	0.0010	0.0013	0.0082
L. amylophilus	0.0017	0.0020	0.0000	0.0035
unidentified *Lactobacillus* spp.	0.0021	0.0011	0.0013	0.0004

Supplementary File 24

Non-*Lactobacillus taxa* descriptive statistics (laser-only group)

Taxon/Time	N	Mean (%)	SD (%)
Cutibacterium/T=0	40	0.1	0.27
Cutibacterium/T=90	40	0.09	0.16
Mycoplasma/T=0	40	0.1	0.62
Mycoplasma/T=90	40	0.01	0.03
Christensenellaceae R-7 group/T=0	40	0.12	0.41
Christensenellaceae R-7 group/T=90	40	0.1	0.23
Ureaplasma/T=0	40	0.13	0.34
Ureaplasma/T=90	40	0.14	0.52
Actinobaculum/T=0	40	0.14	0.75
Actinobaculum/T=90	40	0.02	0.1

Parabacteroides/T=0	40	0.15	0.67
Parabacteroides/T=90	40	0.08	0.21
Blautia/T=0	40	0.15	0.6
Blautia/T=90	40	0.15	0.54
Ruminococcus/T=0	40	0.18	0.81
Ruminococcus/T=90	40	0.15	0.49
Subdoligranulum/T=0	40	0.18	0.7
Subdoligranulum/T=90	40	0.12	0.32
Escherichia-Shigella/T=0	40	0.2	0.72
Escherichia-Shigella/T=90	40	2.33	11.08
Gemella/T=0	40	0.2	0.72
Gemella/T=90	40	0.2	0.42
U. m. of Lachnospiraceae family/T=0	40	0.21	0.47
U. m. of Lachnospiraceae family/T=90	40	0.29	0.51
Veillonella/T=0	40	0.23	0.71
Veillonella/T=90	40	0.15	0.5
Megasphaera/T=0	40	0.24	1.26
Megasphaera/T=90	40	0.37	1.76
Enterococcus/T=0	40	0.26	1.47
Enterococcus/T=90	40	0.3	1.1
Porphyromonas/T=0	40	0.27	1.59
Porphyromonas/T=90	40	0.04	0.18
Actinomyces/T=0	40	0.28	0.89
Actinomyces/T=90	40	0.19	0.81

Aerococcus/T=0	40	0.28	0.99
Aerococcus/T=90	40	0.18	0.93
Howardella/T=0	40	0.28	1.21
Howardella/T=90	40	0.17	0.36
Alistipes/T=0	40	0.29	0.74
Alistipes/T=90	40	0.16	0.3
Streptomyces/T=0	40	0.3	1.09
Streptomyces/T=90	40	0.03	0.09
Eubacterium eligens group/T=0	40	0.3	0.76
Eubacterium eligens group/T=90	40	0.22	0.37
Corynebacterium/T=0	40	0.31	0.83
Corynebacterium/T=90	40	0.08	0.15
Alloscardovia/T=0	40	0.32	1.23
Alloscardovia/T=90	40	0.69	3.52
Anaerococcus/T=0	40	0.37	0.97
Anaerococcus/T=90	40	0.35	1.24
Peptoniphilus/T=0	40	0.4	1.18
Peptoniphilus/T=90	40	0.15	0.36
Finegoldia/T=0	40	0.46	1.32
Finegoldia/T=90	40	0.19	0.46
U. m. of Ruminococcaceae family/T=0	40	0.46	1.06
U. m. of Ruminococcaceae family/T=90	40	0.26	0.6
Fusobacterium/T=0	40	0.54	1.37
Fusobacterium/T=90	40	0.13	0.35

Staphylococcus/T=0	40	0.89	5.28
Staphylococcus/T=90	40	0.08	0.24
Dialister/T=0	40	0.92	1.46
Dialister/T=90	40	0.54	0.9
Proteus/T=0	40	1.04	6.6
Proteus/T=90	40	0.01	0.05
Klebsiella/T=0	40	1.31	8.13
Klebsiella/T=90	40	0.4	2.36
Faecalibacterium/T=0	40	1.63	3.29
Faecalibacterium/T=90	40	1.37	2.49
Bacteroides/T=0	40	1.85	3.3
Bacteroides/T=90	40	1.07	1.68
Sneathia/T=0	40	2.05	10.06
Sneathia/T=90	40	3.22	15.43
Atopobium/T=0	40	2.41	7.29
Atopobium/T=90	40	2.36	7.3
Haemophilus/T=0	40	2.84	15.39
Haemophilus/T=90	40	0.08	0.22
Others rare vaginal bacteria/T=0	40	2.88	5.73
Others rare vaginal bacteria/T=90	40	1.79	2.77
Pseudomonas/T=0	40	4.87	19.96
Pseudomonas/T=90	40	2.42	13.62
Bifidobacterium/T=0	40	5.78	20.01
Bifidobacterium/T=90	40	6.47	18.74
Prevotella/T=0	40	7.14	18.72
Prevotella/T=90	40	6.46	11.32

Streptococcus/T=0	40	9.43	19.66
Streptococcus/T=90	40	11.32	24.28
Gardnerella/T=0	40	16.39	28.44
Gardnerella/T=90	40	18.35	30.59

Supplementary File 25

Non-*Lactobacillus taxa* descriptive statistics (probiotic plus laser group)

Taxon/Time	N	Mean (%)	SD (%)
Veillonella/T=0	21	0.11	0.4
Veillonella/T=90	21	0.05	0.15
Alistipes/T=0	21	0.12	0.33
Alistipes/T=90	21	0.05	0.11
Peptostreptococcus/T=0	21	0.12	0.34
Peptostreptococcus/T=90	21	0	0
Staphylococcus/T=0	21	0.12	0.45
Staphylococcus/T=90	21	0.03	0.05
U. m. of Lachnospiraceae family/T=0	21	0.15	0.24
U. m. of Lachnospiraceae family/T=90	21	0.06	0.11

Aerococcus/T=0	21	0.16	0.46
Aerococcus/T=90	21	0.33	1.27
U. m. of Eggerthellaceae family/T=0	21	0.18	0.71
U. m. of Eggerthellaceae family/T=90	21	0.13	0.5
Actinomyces/T=0	21	0.2	0.62
Actinomyces/T=90	21	0.51	1.76
Bacillus/T=0	21	0.2	0.64
Bacillus/T=90	21	0.07	0.27
U. m. of Ruminococcaceae family/T=0	21	0.2	0.38
U. m. of Ruminococcaceae family/T=90	21	0.1	0.2
Cutibacterium/T=0	21	0.21	0.64
Cutibacterium/T=90	21	0.85	3.73
Parasutterella/T=0	21	0.21	0.81
Parasutterella/T=90	21	0	0.01
Klebsiella/T=0	21	0.25	1.13
Klebsiella/T=90	21	0	0
Finegoldia/T=0	21	0.27	0.71
Finegoldia/T=90	21	1.61	4.7
Dialister/T=0	21	0.31	0.53
Dialister/T=90	21	0.84	2.1
Fastidiosipila/T=0	21	0.32	1.46
Fastidiosipila/T=90	21	0.4	1.84
Alloscardovia/T=0	21	0.34	1.43
Alloscardovia/T=90	21	3.58	16.31

Anaerococcus/T=0	21	0.41	1.64
Anaerococcus/T=90	21	1.54	4.47
Peptoniphilus/T=0	21	0.5	1.64
Peptoniphilus/T=90	21	2.95	9.96
Bacteroides/T=0	21	0.54	0.94
Bacteroides/T=90	21	0.46	0.77
Faecalibacterium/T=0	21	0.57	1.03
Faecalibacterium/T=90	21	0.32	0.51
Others rare vaginal bacteria/T=0	21	0.66	0.96
Others rare vaginal bacteria/T=90	21	1.53	4.16
Pseudomonas/T=0	21	1.37	4.71
Pseudomonas/T=90	21	3.68	10.91
Enterococcus/T=0	21	1.38	5.83
Enterococcus/T=90	21	0.1	0.34
Megasphaera/T=0	21	1.44	4.57
Megasphaera/T=90	21	0.15	0.7
Prevotella/T=0	21	2.53	5.05
Prevotella/T=90	21	5.13	11.3
Escherichia-Shigella/T=0	21	2.75	11.99
Escherichia-Shigella/T=90	21	0.18	0.73
Atopobium/T=0	21	3.31	9.77
Atopobium/T=90	21	1.52	3.85
Ureaplasma/T=0	21	4.71	16.93
Ureaplasma/T=90	21	0.3	1.11
Streptococcus/T=0	21	9.01	22.6
Streptococcus/T=90	21	16.96	32.62

Bifidobacterium/T=0	21	11.8	24.22
Bifidobacterium/T=90	21	5.39	21.31
Gardnerella/T=0	21	11.86	20.76
Gardnerella/T=90	21	18.46	32.24