Supporting Information

Effects of different grazing disturbances on the plant diversity and ecological functions of alpine grassland ecosystem on the Qinghai-Tibetan Plateau

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Table **S1**. Fail-safe numbers of Rosenthal’s method for assessing publication bias of tested response variables in this meta-analysis.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | Number of studies | 5n+10 | Rosenthal's Fail-safe number |
| Species richness | 38 | 200 | 651.3 |
| Shannon-Wiener index | 35 | 185 | 309.6 |
| Pielou evenness index | 30 | 160 | **33.3** |
| AGB | 63 | 325 | 38164.4 |
| BGB | 55 | 285 | 1708.0 |
| SOC | 126 | 640 | 15368.2 |
| TN | 163 | 825 | 29494.4 |
| C:N ratio | 55 | 285 | 348.9 |
| BD | 74 | 380 | 7094.7 |
| SM | 38 | 200 | 3385771.1 |
| pH | 72 | 72 | 30991.4 |

Note: Bold type indicates possible publication bias.

**Table S2.** The weight response ratio and 95% CI of each subgroup in meta-analysis determining the effect of grazing on grasslandplant diversity. The *Q* values of each subgroup in the meta-analysis determining the influence of grazing on plant diversity.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **Group** | **n** | ***RR++*** | **95% CI** | **Percentage (%)** | *QB* | *QW* | *QT* |
| Species richness | All | 38 | 0.0943 | 0.0271 to 0.1578 | 9.89 | — | — | 29.6526 |
| LG | 5 | 0.0126 | -0.0517 to 0.0689 | 1.27 | 3.4694 | 26.3574 | 29.8268 |
| MG | 10 | 0.1722 | 0.0206 to 0.3268 | 18.79 |
| HG | 10 | 0.0205 | -0.1260 to 0.1479 | 2.07 |
| FG | 13 | 0.1231 | 0.0332 to 0.1945 | 13.10 |
| Short | 6 | 0.0098 | -0.1538 to 0.1499 | 0.98 | 1.3265 | 28.2556 | 29.5821 |
| Medium | 13 | 0.0914 | -0.0284 to 0.2112 | 9.57 |
| Long | 19 | 0.1295 | 0.0047 to 0.2559 | 13.83 |
| Summer | 30 | 0.0456 | -0.0240 to 0.1102 | 4.67 | 11.6506\*\* | 31.0369 | 42.6875 |
| Winter | 5 | 0.2989 | 0.1338 to 0.4425 | 34.84 |
| Annual | 3 | 0.1266 | 0.0704 to 0.2544 | 13.50 |
| Tibetan sheep | 10 | -0.0036 | -0.0680 to 0.0691 | -0.36 | 29.6749\*\* | 23.6965 | 53.3714 |
| Yak | 20 | 0.0267 | -0.0515 to 0.0843 | 2.71 |
| Mixed | 8 | 0.3158 | 0.2316 to 0.4250 | 37.14 |
| Alpine meadow | 35 | 0.1045 | 0.0344 to 0.1746 | 11.02 | 0.4125 | 28.3840 | 28.7965 |
| Alpine steppe | 2 | 0.0095 | -0.1040 to 0.0704 | 0.95 |
| Alpine desert steppe | 1 | -0.1194 | - | -11.25 |
| Shannon-Wiener index | All | 35 | 0.0703 | 0.0167 to 0.1277 | 7.28 | — | — | 34.1291 |
| LG | 5 | 0.0645 | 0.0071 to 0.1571 | 6.66 | 2.8319 | 29.9093 | 32.7413 |
| MG | 9 | 0.1475 | 0.0361 to 0.2779 | 15.89 |
| HG | 9 | 0.0166 | -0.1034 to 0.1324 | 1.67 |
| FG | 12 | 0.0623 | -0.0167 to 0.1508 | 6.43 |
| Short | 2 | -0.1387 | -0.1903 to -0.0725 | -12.95 | 2.6763 | 28.5781 | 31.2544 |
| Medium | 16 | 0.0895 | 0.0067 to 0.1729 | 9.36 |
| Long | 17 | 0.0746 | 0.0027 to 0.1599 | 7.75 |
| Summer | 27 | 0.0411 | -0.0138 to 0.0957 | 4.20 | 4.7030 | 27.1135 | 31.8165 |
| Winter | 4 | 0.2357 | 0.0291 to 0.4757 | 26.58 |
| Annual | 4 | 0.1469 | 0.0264 to 0.3732 | 15.82 |
| Tibetan sheep | 13 | 0.0971 | 0.0357 to 0.1702 | 10.20 | 0.7726 | 35.9729 | 36.7455 |
| Yak | 12 | 0.0398 | -0.0429 to 0.1095 | 4.06 |
| Mixed | 10 | 0.0696 | -0.0582 to 0.2292 | 7.21 |
| Alpine meadow | 28 | 0.0478 | -0.0114 to 0.1099 | 4.90 | 3.4074 | 30.5340 | 33.9414 |
| Alpine steppe | 5 | 0.1689 | 0.0523 to 0.2918 | 18.40 |
| Alpine desert steppe | 2 | 0.3059 | 0.0009 to 0.6251 | 35.78 |
| Pielou evenness index | All | 30 | 0.0367 | 0.0139 to 0.0632 | 3.74 | — | — | 27.9676 |
| LG | 4 | 0.0582 | 0.0029 to 0.1136 | 5.99 | 7.9444\* | 20.7090 | 28.6534 |
| MG | 9 | 0.0968 | -0.0306 to 0.1389 | 10.16 |
| HG | 9 | 0.0122 | -0.0771 to 0.0502 | 1.23 |
| FG | 8 | 0.0409 | 0.0242 to 0.0624 | 4.17 |
| Short | 2 | -0.0968 | -0.2701 to -0.0427 | -9.23 | 5.8055 | 22.8479 | 28.6534 |
| Medium | 14 | 0.0101 | -0.0467 to 0.0472 | 1.02 |
| Long | 14 | 0.0439 | 0.0204 to 0.0822 | 4.49 |
| Summer | 22 | 0.0329 | -0.0162 to 0.0733 | 3.34 | 3.6442 | 25.0092 | 28.6534 |
| Winter | 4 | 0.0612 | 0.0166 to 0.1712 | 6.31 |
| Annual | 4 | 0.0549 | -0.0056 to 0.1153 | 5.64 |
| Tibetan sheep | 10 | 0.0776 | 0.0645 to 0.1383 | 8.07 | 11.3900\*\* | 17.2634 | 28.6534 |
| Yak | 14 | 0.0125 | -0.0091 to 0.0281 | 1.26 |
| Mixed | 6 | 0.0484 | 0.0024 to 0.1153 | 4.96 |
| Alpine meadow | 25 | 0.0267 | -0.0087 to 0.0558 | 2.71 | 0.3870 | 26.0084 | 26.3954 |
| Alpine steppe | 4 | 0.111 | 0.0294 to 0.16 | 11.74 |
| Alpine desert steppe | 1 | 0.1671 | - | 18.19 |

Note: \*, *P* < 0.05; \*\*, *P* < 0.01.

LG, light grazing; MG, moderate grazing; HG, heavy grazing; FG, free grazing. The grazing duration are classified as short grazing duration (≤2 years), Medium grazing duration (2-5 years), and long grazing duration (＞5 years)

**Table S3.** The weight response ratio and 95% CI of each subgroup in meta-analysis determining the effect of grazing on grasslandbiomass. The *Q* values of each subgroup in the meta-analysis determining the influence of grazing on grasslandbiomass.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **Group** | **n** | ***RR++*** | **95% CI** | **Percentage (%)** | *QB* | *QW* | *QT* |
| AGB | All | 63 | -0.5432 | -0.7116 to -0.3987 | -41.91 | — | — | 31.6976 |
| LG | 8 | -0.2122 | -0.6453 to -0.4138 | -19.12 | 2.7092 | 14.6023 | 17.3115 |
| MG | 14 | -0.4581 | -0.3718 to -0.0167 | -36.75 |
| HG | 15 | -0.808 | -0.6967 to -0.2507 | -55.43 |
| FG | 26 | -0.4913 | -0.6108 to -0.3785 | -38.82 |
| Short | 18 | -0.8720 | -0.9296 to -0.8145 | -58.19 | 181.3017\*\* | 1314.9388 | 1496.2405 |
| Medium | 27 | -0.4481 | -0.4852 to -0.4111 | -36.12 |
| Long | 18 | -0.4588 | -0.5196 to -0.3979 | -36.80 |
| Summer | 48 | -0.5826 | -0.7859 to -0.3978 | -44.16 | 24.3450\*\* | 776.2282 | 800.5732 |
| Winter | 9 | -0.345 | -0.4754 to -0.2506 | -29.18 |
| Annual | 6 | -0.5663 | -0.7937 to -0.3709 | -43.24 |
| Tibetan sheep | 8 | -0.3142 | -0.442 to -0.1865 | -26.96 | 315.7083\*\* | 1446.8422 | 1762.5505 |
| Yak | 18 | -0.2003 | -0.507 to -0.0529 | -18.15 |
| Mixed | 37 | -0.697 | -0.9229 to -0.4971 | -50.19 |
| Alpine meadow | 58 | -0.5431 | -0.703 to -0.3936 | -41.91 | 0.0002 | 789.1089 | 789.1091 |
| Alpine steppe | 4 | -0.5446 | -0.8866 to -0.2026 | -41.99 |
| Alpine desert steppe | 1 | -0.5994 | - | -45.09 |
| BGB | All | 55 | -0.1946 | -0.3139 to -0.0891 | -17.68 | — | — | 32.4485 |
| LG | 7 | -0.1908 | -0.58 to 0.1983 | -17.37 | 4.3468 | 29.9588 | 34.3056 |
| MG | 13 | 0.0171 | -0.1526 to 0.2058 | 1.72 |
| HG | 9 | -0.3762 | -0.7053 to -0.0471 | -31.35 |
| FG | 26 | -0.1712 | -0.2569 to -0.0824 | -15.73 |
| Short | 12 | -0.0633 | -0.2537 to 0.0367 | -6.13 | 14.3072\*\* | 268.2532 | 282.5604 |
| Medium | 28 | -0.2613 | -0.4428 to -0.0849 | -23.00 |
| Long | 15 | -0.1718 | -0.2851 to -0.0158 | -15.78 |
| Summer | 38 | -0.2726 | -0.4242 to -0.1338 | -23.86 | 27.9420\*\* | 190.8439 | 218.7859 |
| Winter | 13 | 0.0066 | -0.0697 to 0.0918 | 0.66 |
| Annual | 4 | -0.1281 | -0.3244 to -0.0386 | -12.02 |
| Tibetan sheep | 17 | -0.0524 | -0.1972 to 0.0647 | -5.11 | 14.1444\*\* | 207.0911 | 221.2356 |
| Yak | 10 | -0.2855 | -0.3554 to -0.126 | -24.84 |
| Mixed | 28 | -0.2362 | -0.4187 to -0.0832 | -21.04 |
| Alpine meadow | 52 | -0.1955 | -0.3168 to -0.0888 | -17.76 | 0.0005 | 218.7503 | 218.7503 |
| Alpine steppe | 2 | -0.1923 | -0.2941 to -0.1136 | -17.49 |
| Alpine desert steppe | 1 | -0.0636 |  | -6.16 |

Note: \*, *P* < 0.05; \*\*, *P* < 0.01.

AGB, aboveground biomass; BGB, belowground biomass; LG, light grazing; MG, moderate grazing; HG, heavy grazing; FG, free grazing. The grazing duration are classified as short grazing duration (≤2 years), Medium grazing duration (2-5 years), and long grazing duration (＞5 years)

**Table S4.** The weight response ratio and 95% CI of each subgroup in meta-analysis determining the effect of grazing on grassland soil C, N, and related variables. The Q values of each subgroup in the meta-analysis determining the influence of grazing on soil property.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **Group** | **n** | ***RR++*** | **95% CI** | **Percentage (%)** | *QB* | *QW* | *QT* |
| SOC | All | 126 | -0.1399 | -0.1804 to -0.1020 | -13.06 | — | — | 162.4508 |
| LG | 21 | -0.0204 | -0.0641 to 0.0245 | -2.02 | 64.4895\*\* | 152.7415 | 217.2310 |
| MG | 29 | -0.0547 | -0.0974 to -0.0158 | -5.32 |
| HG | 30 | -0.1007 | -0.1516 to -0.0542 | -9.58 |
| FG | 46 | -0.2982  | -0.3772 to -0.2182 | -25.78 |
| Short | 26 | -0.0417 | -0.0919 to 0.0085 | -4.08 | 33.9793\*\* | 172.9927 | 206.9720 |
| Medium | 79 | -0.1477 | -0.2050 to -0.0990 | -13.73 |
| Long | 21 | -0.2863 | -0.3757 to -0.1909 | -24.90 |
| Summer | 70 | -0.1173 | -0.1608 to -0.0753 | -11.07 | 5.6571 | 166.9198 | 172.5769 |
| Winter | 29 | -0.1254  | -0.1949 to -0.0724 | -11.79 |
| Annual | 27 | -0.2084 | -0.3294 to -0.0986 | -18.81 |
| Tibetan sheep | 30 | -0.1047 | -0.1725 to -0.0401 | -9.94 | 5.6401 | 143.355 | 148.9957 |
| Yak | 51 | -0.1137 | -0.1809 to -0.0539 | -10.75 |
| Mixed | 45 | -0.1939 | -0.269 to -0.1287 | -17.63 |
| Alpine meadow | 106 | -0.1558 | -0.2022 to -0.1121 | -14.43 | 5.5395 | 152.0696 | 157.6091 |
| Alpine steppe | 18 | -0.0472 | -0.0971 to 0.001 | -4.61 |
| Alpine desert steppe | 2 | -0.2257 | -0.3789 to 0.114 | -20.20 |
| TN | All | 163 | -0.1349 | -0.1905 to -0.0900 | -12.62 | — | — | 246.2211 |
| LG | 26 | -0.0097 | -0.0889 to 0.644 | -0.97 | 38.4248\*\* | 271.8128 | 310.2375 |
| MG | 42 | -0.0618 | -0.121 to -0.0123 | -5.99 |
| HG | 45 | -0.1163 | -0.1785 to -0.0651 | -10.98 |
| FG | 50 | -0.2971 | -0.4478 to-0.1816 | -25.70 |
| Short | 45 | -0.0551 | -0.0933 to -0.0182 | -5.36 | 11.8679\*\* | 272.9678 | 284.8357 |
| Medium | 87 | -0.1692 | -0.2659 to -0.0969 | -15.57 |
| Long | 31 | -0.2048 | -0.3242 to -0.0847 | -18.52 |
| Summer | 105 | -0.0995 | -0.1426 to -0.0602 | -9.47 | 13.5974\*\* | 245.6338 | 259.2312 |
| Winter | 28 | -0.32 | -0.6913 to -0.1141 | -27.39 |
| Annual | 30 | -0.154 | -0.2441 to -0.0656 | -14.27 |
| Tibetan sheep | 31 | -0.1569 | -0.2457 to -0.0786 | -14.52 | 20.1492\*\* | 257.6815 | 277.8306 |
| Yak | 87 | -0.0573 | -0.0946 to -0.021 | -5.57 |
| Mixed | 45 | -0.2466 | -0.4064 to -0.1328 | -21.85 |
| Alpine meadow | 144 | -0.1492 | -0.2069 to -0.0995 | -13.86 | 5.0190 | 242.4348 | 247.4538 |
| Alpine steppe | 17 | -0.009 | -0.0613 to 0.0442 | -0.90 |
| Alpine desert steppe | 2 | -0.188 | -0.3834 to 0.1374 | -17.14 |
| S:N ratio | All | 55 | -0.0332 | -0.0432 to -0.0206 | -3.27 | — | — | 45.5109 |
| LG | 10 | -0.0408 | -0.072 to 0.0058 | -4.00 | 1.8775 | 43.4712 | 45.3486 |
| MG | 13 | -0.0287 | -0.0416 to -0.0113 | -2.83 |
| HG | 16 | -0.0297 | -0.0493 to -0.01 | -2.93 |
| FG | 16 | -0.0496 | -0.0742 to -0.036 | -4.84 |
| Short | 4 | -0.0111 | -0.0380 to 0.0000 | -1.10 | 4.1083 | 41.2403 | 45.2403 |
| Medium | 36 | -0.0250 | -0.0544 to -0.0048 | -2.47 |
| Long | 15 | -0.0419 | -0.0580 to -0.0354 | -4.10 |
| Summer | 33 | -0.0372 | -0.048 to -0.0234 | -3.65 | 3.6896 | 41.6590 | 45.3486 |
| Winter | 6 | -0.0628 | -0.1311 to 0.0054 | -6.09 |
| Annual | 16 | -0.0185 | -0.0457 to 0.0037 | -1.83 |
| Tibetan sheep | 13 | -0.0187 | -0.0474 to 0.0032 | -1.85 | 2.9493 | 42.3994 | 45.3486 |
| Yak | 25 | -0.0405 | -0.0547 to -0.0282 | -3.97 |
| Mixed | 17 | -0.0336 | -0.0671 to -0.0124 | -3.30 |
| Alpine meadow | 43 | -0.0386 | -0.0493 to -0.0276 | -3.79 | 2.8124 | 42.5362 | 45.3486 |
| Alpine steppe | 12 | -0.0184 | -0.0463 to 0.0044 | -1.82 |
| Alpine desert steppe | - | - | - | - |
| BD | All | 74 | 0.1609 | 0.1114 to 0.2141 | 17.46 | — | — | 94.2894 |
| LG | 10 | 0.1104 | 0.0192 to 0.2313 | 11.67 | 0.6772 | 81.8404 | 82.5176 |
| MG | 19 | 0.1568 | 0.0783 to 0.2501 | 16.98 |
| HG | 20 | 0.1746 | 0.0791 to 0.3014 | 19.08 |
| FG | 25 | 0.172 | 0.0823 to 0.2685 | 18.77 |
| Short | 27 | 0.2270 | 0.1247 to 0.3463 | 25.48 | 16.9580\*\* | 87.1074 | 104.0655 |
| Medium | 35 | 0.0716 | 0.0295 to 0.1177 | 7.42 |
| Long | 12 | 0.2842 | 0.1637 to 0.4143 | 32.87 |
| Summer | 47 | 0.2053 | 0.1437 to 0.2741 | 22.79 | 7.7633 | 81.7625 | 86.5258 |
| Winter | 6 | 0.125 | 0.0449 to 0.2379 | 13.31 |
| Annual | 21 | 0.0952 | 0.0083 to 0.1946 | 9.99 |
| Tibetan sheep | 28 | 0.2983 | 0.1884 to 0.4164 | 34.76 | 26.2786\*\* | 82.4564 | 108.7351 |
| Yak | 27 | 0.1207 | 0.0771 to 0.1653 | 12.83 |
| Mixed | 19 | 0.0415 | -0.0017 to 0.0884 | 4.24 |
| Alpine meadow | 58 | 0.2038 | 0.1428 to 0.2697 | 22.61 | 11.5115\*\* | 84.7429 | 96.2545 |
| Alpine steppe | 14 | 0.0418 | -0.0095 to 0.1036 | 4.27 |
| Alpine desert steppe | 2 | -0.049 | -0.1039 to -0.0072 | -4.78 |
| SM | All | 38 | -0.2326 | -0.3298 to -0.1449 | -20.75 | — | — | 30.5461 |
| LG | 4 | -0.1073 | -0.258 to 0.0298 | -10.17 | 13.2420\*\* | 29.1551 | 42.3971 |
| MG | 10 | -0.0618 | -0.1129 to -0.0224 | -5.99 |
| HG | 7 | -0.0884 | -0.2828 to -0.0074 | -8.46 |
| FG | 17 | -0.4017 | -0.5418 to -0.2637 | -33.08 |
| Short | 12 | -0.0473 | -0.0760 to -0.0183 | -4.62 | 9.1331\* | 35.2641 | 44.3972 |
| Medium | 13 | -0.2985 | -0.4692 to -0.1318 | -25.81 |
| Long | 13 | -0.3504 | -0.5259 to -0.1862 | -29.56 |
| Summer | 21 | -0.0498 | -0.0783 to -0.0221 | -4.86 | 274.5990\*\* | 76.0640 | 350.6630 |
| Winter | 8 | -0.1836 | -0.258 to -0.1054 | -16.77 |
| Annual | 9 | -0.6401 | -0.7387 to -0.5028 | -47.28 |
| Tibetan sheep | 8 | -0.3511 | -0.59 to -0.1216 | -29.61 | 1.7711 | 29.8012 | 31.5723 |
| Yak | 9 | -0.1362 | -0.3157 to -0.0203 | -12.73 |
| Mixed | 21 | -0.226 | -0.3453 to -0.121 | -20.23 |
| Alpine meadow | 37 | -0.239 | -0.3363 to -0.1484 | -21.26 | - | - | 31.5655 |
| Alpine steppe | 1 | -0.0129 | - | -1.28 |
| Alpine desert steppe | - | - | - | - |
| Soil pH | All | 72 | 0.0222 | 0.0100 to 0.0358 | 2.24 | — | — | 69.1205 |
| LG | 8 | 0.0109 | -0.0511 to 0.0791 | 1.10 | 2.1594 | 29.2684 | 31.4278 |
| MG | 14 | 0.0279 | 0.0044 to 0.0611 | 2.83 |
| HG | 18 | 0.0437 | 0.0155 to 0.0779 | 4.47 |
| FG | 32 | 0.0095 | 0.0001 to 0.0195 | 0.95 |
| Short | 11 | 0.0189 | 0.0038 to 0.0453 | 1.91 | 21.8274\*\* | 142.9228 | 164.7503 |
| Medium | 38 | 0.0102 | 0.003 to 0.0174 | 1.03 |
| Long | 23 | 0.0574 | 0.0127 to 0.1029 | 5.91 |
| Summer | 34 | 0.0292 | 0.0045 to 0.0559 | 2.96 | 1.8654 | 43.1508 | 45.0162 |
| Winter | 12 | -0.0056 | -0.0188 to 0.0052 | -0.56 |
| Annual | 26 | 0.0227 | 0.0143 to 0.0314 | 2.30 |
| Tibetan sheep | 13 | 0.0815 | 0.0288 to 0.1282 | 8.49 | 59.0340\*\* | 144.7149 | 203.7489 |
| Yak | 12 | 0.004 | -0.0065 to 0.0078 | 0.04 |
| Mixed | 47 | 0.0128 | 0.0039 to 0.0224 | 1.29 |
| Alpine meadow | 53 | 0.0238 | 0.0082 to 0.0415 | 2.41 | 0.2376 | 45.1428 | 45.3804 |
| Alpine steppe | 17 | 0.0193 | 0.0073 to 0.0303 | 1.95 |
| Alpine desert steppe | 2 | 0.0029 | -0.0024 to 0.0083 | 0.29 |

\*, *P* < 0.05; \*\*, *P* < 0.01.

SOC, soil organic carbon; TN, soil total nitrogen; SCN, soil C: N ratio, BD, soil bulk density; SM, soil moisture. LG, light grazing; MG, moderate grazing; HG, heavy grazing; FG, free grazing. The grazing duration are classified as short grazing duration (≤2 years), Medium grazing duration (2-5 years), and long grazing duration (＞5 years)

**Text S1 Studies included in the current meta-analysis**

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3. Chen DD, Sun DS, Zhang SH, Tan YR, Du GZ, Shi XM (2011) Effect of grazing intensity on soil microbial characteristics of an alpine meadow on the tibetan plateau. Journal of Lanzhou University (Natural Sciences) 47: 73-81. (In Chinese)
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