**Supplementary Table 1 The abbreviations and accession numbers of carlaviruses used in the present study**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Full Name | Abbreviations | GenBank Acc Nos. | ORF1 | ORF2 | ORF3 | ORF4 | ORF5 | ORF6 |
| *Aconitum latent virus* | AcLV | NC\_002795 | NP\_116487 | NP\_116488 | NP\_116489 | NP\_116490 | NP\_116491 | NP\_116492 |
| *Alfalfa latent virus* | ALV | NC\_026616 | YP\_009126731 | YP\_009126732 | YP\_009126733 | YP\_009126734 | YP\_009126735 | - |
| *American hop latent virus* | AHLV | NC\_017859 | YP\_006297586 | YP\_006297587 | YP\_006297588 | YP\_006297589 | YP\_006297590 | YP\_006297591 |
| *Blueberry scorch virus* | BBScV | NC\_003499 | NP\_612579 | NP\_612809 | NP\_612810 | NP\_612811 | NP\_612812 | NP\_612813 |
| *Butterbur mosaic virus* | ButMV | NC\_013527 | YP\_003324581 | YP\_003324582 | YP\_003324583 | YP\_003324584 | YP\_003324585 | YP\_003324586 |
| *Caper latent virus* | CapLV | HQ588147/148 | - | - | - | - | AEF12643 | - |
| *Chrysanthemum virus B* | CVB | NC\_009087 | YP\_001086452.2 | YP\_001086453 | YP\_001086454 | YP\_001086455 | YP\_001086456 | YP\_001086457 |
| *Cole latent virus* | CoLV | AY340584 | - | - | - | - | AAQ19967 | AAQ19968 |
| *Coleus vein necrosis virus* | CVNV | NC\_009764 | YP\_001430021 | YP\_001430022 | YP\_001430023 | YP\_001430024 | YP\_001430025 | YP\_001430026 |
| *Cowpea mild mottle virus* | CPMMV | NC\_014730 | YP\_004035878 | YP\_004035879 | YP\_004035880 | YP\_004035881 | YP\_004035882 | YP\_004035883 |
| *Cucumber vein-clearing virus* | CuVCV | JN591720 | - | AEP83727 | AEP83728 | AEP83729 | AEP83730 | AEP83731 |
| *Daphne virus S* | DVS | NC\_008020 | YP\_595727 | YP\_595728 | YP\_595729 | YP\_595730 | YP\_595731 | YP\_595732 |
| *Elderberry carlavirus A* | EBCVA | NC\_029085 | YP\_009224928 | YP\_009224929 | YP\_009224930 | YP\_009224931 | YP\_009224932 | YP\_009224933 |
| *Elderberry carlavirus B* | EBCVB | NC\_029086 | YP\_009224934 | YP\_009224935 | YP\_009224936 | YP\_009224937 | YP\_009224938 | YP\_009224939 |
| *Elderberry carlavirus C* | EBCVC | NC\_029087 | YP\_009224940 | YP\_009224941 | YP\_009224942 | YP\_009224943 | YP\_009224944 | YP\_009224945 |
| *Elderberry carlavirus D* | EBCVD | NC\_029088 | YP\_009224946 | YP\_009224947 | YP\_009224948 | YP\_009224949 | YP\_009224950 | YP\_009224951 |
| *Elderberry carlavirus E* | EBCVE | NC\_029089 | YP\_009224952 | YP\_009224953 | YP\_009224954 | YP\_009224955 | YP\_009224956 | YP\_009224957 |
| *Gaillardia latent virus* | GalLV | NC\_023892 | YP\_009022064 | YP\_009022065 | YP\_009022066 | YP\_009022067 | YP\_009022068 | YP\_009022069 |
| *Garlic common latent virus* | GCLV | NC\_016440 | YP\_004936159 | YP\_004936160 | YP\_004936161 | YP\_004936162 | YP\_004936163 | YP\_004936164 |
| *Garlic latent virus* | GLV | NC\_003557 | NP\_619559 | NP\_619560 | NP\_619561 | NP\_619562 | NP\_619563 | NP\_619564 |
| *Helleborus mosaic virus* | HeMV | FJ196838  | - | ACM45998 | ACM45999 | ACM46000 | ACM46001 | ACM46002 |
| *Helleborus net necrosis virus* | HeNNV | NC\_012038 | YP\_002574614 | YP\_002574615 | YP\_002574616 | YP\_002574617 | YP\_002574618 | YP\_002574619 |
| *Hippeastrum latent virus* | HLV | NC\_011540 | YP\_002308447 | YP\_002308448 | YP\_002308449 | YP\_002308450 | YP\_002308451 | YP\_002308452 |
| *Hop latent virus* | HpLV | NC\_002552 | NP\_066258 | NP\_066259 | NP\_066260 | NP\_066261 | NP\_066262 | NP\_066263 |
| *Hop mosaic virus* | HpMV | NC\_010538 | YP\_001798592 | YP\_001798593 | YP\_001798594 | YP\_001798595 | YP\_001798596 | YP\_001798597 |
| *Hydrangea chlorotic mottle virus* | HdCMV | NC\_012869 | YP\_002985636 | YP\_002985637 | YP\_002985638 | YP\_002985639 | YP\_002985640 | YP\_002985641 |
| *Jasmine virus C* | JaVC | NC\_030926 | YP\_009275350 | YP\_009275351 | YP\_009275352 | YP\_009275353 | YP\_009275354 | YP\_009275355 |
| *Kalanchoe latent virus* | KLV | NC\_013006 | YP\_003075957 | YP\_003075958 | YP\_003075959 | YP\_003075961 | YP\_003075962 | YP\_003075963 |
| *Ligustrum necrotic ringspot virus* | LNRSV | NC\_010305 | YP\_001661446 | YP\_001661447 | YP\_001661448 | YP\_001661449 | YP\_001661450 | YP\_001661451 |
| *Ligustrum virus A* | LVA | NC\_031089 | YP\_009288956 | YP\_009288957 | YP\_009288958 | YP\_009288959 | YP\_009288960 | YP\_009288961 |
| *Lily symptomless virus* | LSV | NC\_005138 | NP\_932788 | NP\_932789 | NP\_932790 | NP\_932791 | NP\_932792 | NP\_932793 |
| *Melon yellowing-associated virus* | MYaV | LC224308 | BAX36552 | BAX36553 | BAX36554 | BAX36555 | BAX36556 | BAX36557 |
| *Mirabilis jalapa mottle virus* | MjMV | NC\_016080 | YP\_004901680 | YP\_004901681 | YP\_004901683 | YP\_004901685 | YP\_004901683 | YP\_004901685 |
| *Narcissus common latent virus* | NCLV | NC\_008266 | YP\_699983 | YP\_699984 | YP\_699985 | YP\_699986 | YP\_699987 | YP\_699988 |
| *Narcissus symptomless virus* | NSV | NC\_008552 | YP\_842438 | YP\_842439 | YP\_842440 | YP\_842441 | YP\_842442 | YP\_842443 |
| *Passiflora latent carlavirus* | PLV | NC\_008292 | YP\_717533 | YP\_717534 | YP\_717535 | YP\_717536 | YP\_717537 | YP\_717538 |
| *Pepper virus A* | PepVA | NC\_034376 | YP\_009357230 | YP\_009357231 | YP\_009357232 | - | YP\_009357233 | YP\_009357234 |
| *Phlox Virus B* | PhlVB | NC\_009991  | YP\_001552317 | YP\_001552318 | YP\_001552319 | YP\_001552320 | YP\_001552321 | YP\_001552322 |
| *Phlox Virus M*  | PhlVM | EF507476 | - | - | - | ABP68909 | ABP68910 | ABP68911 |
| *Phlox Virus S* | PhlVS | NC\_009383 | YP\_001165301 | YP\_001165302 | YP\_001165303 | YP\_001165304 | YP\_001165305 | YP\_001165306 |
| *Poplar mosaic virus* | PopMV | NC\_005343 | NP\_958171 | NP\_958172 | NP\_958173 | NP\_958174 | NP\_958175 | NP\_958176 |
| *Potato latent virus* | PotLV | NC\_011525 | YP\_002302557 | YP\_002302558 | YP\_002302559 | YP\_002302560 | YP\_002302561 | YP\_002302562 |
| *Potato rough dwarf virus* | PRDV | NC\_009759 | YP\_001429585 | YP\_001429586 | YP\_001429587 | YP\_001429588 | YP\_001429589 | YP\_001429590 |
| PVH peppino isolate [Beijing: China:2014] | PVH-BJ | KF546312 | - | AID60175 | AID60176 | AID60177 | AID60178 | AID60179 |
| PVH potato isolate [Yunnan: China:2010] | PVH-YN |  NC\_018175  | YP\_006522434 | YP\_006522435 | YP\_006522436 | YP\_006522437 | YP\_006522438 | YP\_006522439 |
| PVH potato isolate[Inna Mongolia: China: 2010] | PVH-IM | HM584819 | AEI55831 | AEI55832 | AEI55833 | AEI55834 | AEI55835 | AEI55836 |
| *Potato virus M* | PVM | NC\_001361 | NP\_056767 | NP\_056768 | NP\_056769 | NP\_056770 | NP\_056771 | NP\_056772 |
| PVM isolate 18-4 | PVH-BD4 | MF133530 |  |  |  |  |  |  |
| PVM isolate 18-2 | PVH-BD2 | MF133529 |  |  |  |  |  |  |
| PVM isolate 16-3 | PVH-BD3 | MF133528 |  |  |  |  |  |  |
| PVM isolate 16-1 | PVH-BD1 | MF133527 |  |  |  |  |  |  |
| PVM isolate Yunnan | PVM-YN | KY364848 |  |  |  |  |  |  |
| PVM isolate PVM-352 | PVM-352 | JX678982 |  |  |  |  |  |  |
| PVM isolate PVM-Del-144 | PVM-Del-144 | KJ194171 |  |  |  |  |  |  |
| PVM isolate Gansu | PVM-GS | JN835299 |  |  |  |  |  |  |
| PVM isolate VIRUBRA 4/007 | PVM-VIR | HM854296 |  |  |  |  |  |  |
| PVM isolate M57 | PVM-M57 | AY311395 |  |  |  |  |  |  |
| PVM isolate Uran | PVM-Uran | AY311394 |  |  |  |  |  |  |
| PVM isolate DSMZ PV0273 | PVM-DSMZ | EU604672 |  |  |  |  |  |  |
| PVM isolate Hangzhou | PVM-HZ | AJ437481 |  |  |  |  |  |  |
| *Potato virus S* | PVS | NC\_007289 | YP\_277428 | YP\_277429 | YP\_277430 | YP\_277432 | YP\_277433 | YP\_277434 |
| PVS isolate Vltava | PVS-Vltava | AJ863510 |  |  |  |  |  |  |
| PVS isolate BY | PVS-BY | MF033144 |  |  |  |  |  |  |
| PVS isolate Antioquia | PVS-Antioquia | KR152654 |  |  |  |  |  |  |
| PVS isolate NZ-A ab030 Lincoln | PVS-NZ-A | KU058657 |  |  |  |  |  |  |
| PVS isolate NZ-O ab030 Lincoln | PVS-NZ-O | KU058656 |  |  |  |  |  |  |
| PVS isolate Ewa | PVS-Ewa | LN851194 |  |  |  |  |  |  |
| PVS isolate Irena | PVS-Irena | LN851193 |  |  |  |  |  |  |
| PVS isolate Valery | PVS-Valery | LN851192 |  |  |  |  |  |  |
| PVS isolate 09.369 | PVS-09.369 | LN851191 |  |  |  |  |  |  |
| PVS isolate Bonita | PVS-Bonita | LN851190 |  |  |  |  |  |  |
| PVS isolate Alex | PVS-Alex | LN851189 |  |  |  |  |  |  |
| PVS isolate SW-14 | PVS-SW-14 | KP089978 |  |  |  |  |  |  |
| PVS isolate RVC Andean | PVS-RVC Andean | JX419379 |  |  |  |  |  |  |
| PVS isolate Yunnan | PVS-YN | KC430335 |  |  |  |  |  |  |
| PVS isolate BB-AND | PVS-BB-AND | JQ647830 |  |  |  |  |  |  |
| PVS isolate Id4106-US | PVS-Id4106-US | FJ813513 |  |  |  |  |  |  |
| PVS isolate WaDef-US | PVS-WaDef-US | FJ813512 |  |  |  |  |  |  |
| PVS isolate 89.249 | PVS-89.249 | HF571059 |  |  |  |  |  |  |
| PVS isolate HB7 | PVS-HB7 | KU896946 |  |  |  |  |  |  |
| PVS isolate Qld-1 | PVS-Qld-1 | MF375506 |  |  |  |  |  |  |
| PVS isolate GAF318-16.1 | PVS-GAF318-16.1 | KU586451 |  |  |  |  |  |  |
| PVS isolate HB24 | PVS-HB24 | KU896945 |  |  |  |  |  |  |
| *Red clover vein mosaic virus* | RCVMV | NC\_012210 | YP\_002647021 | YP\_002647022 | YP\_002647023 | YP\_002647024 | YP\_002647025 | YP\_002647026 |
| *Sweet potato chlorotic fleck virus* | SPCFV | NC\_006550 | YP\_164258 | YP\_164259 | YP\_164260 | YP\_164261 | YP\_164262 | YP\_164263 |
| *Sweet potato virus C-6* | SPC6V | NC\_018448 | YP\_006589919 | YP\_006589920 | YP\_006589921 | YP\_006589922 | YP\_006589923 | - |
| *Yam latent virus* | YLV | NC\_026248 | YP\_009134730 | YP\_009116869 | YP\_009116870 | YP\_009116871 | YP\_009116872 | YP\_009116873 |

**Supplementary Table 2 The nucleotide and amino acid identities between PVH-HZ and other carlaviruses**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Virus Name | 5'UTR (nt) | RDR (nt/aa) | TGB1 (nt/aa) | TGB2 (nt/aa) | TGB3 (nt/aa) | CP (nt/aa) | CRP (nt/aa) | 3'UTR (nt) |
| PVH-YN | 73.61 | 52.51/66.29 | 71.57/79.57 | 63.61/67.59 | 60.78/59.7 | 73.13/82.19 | 77.10/77.55 | 75.32 |
| PVH-IM | 70.13 | 52.52/66.39 | 69.84/78.7 | 62.39/67.59 | 60.29/59.7 | 71.09/79.45 | 76.43/77.55 | 77.03 |
| PVH-BJ | - | -/- | 70.27/78.7 | 63.91/66.67 | 61.27/61.19 | 73.7/81.16 | 76.77/80.61 | 78.38 |
| PLV | 36.71 | 44.56/34.1 | 54.81/32.62 | 51.99/38.33 | 33.33/25.12 | 51.19/41.78 | 31.67/26.45 | 36.99 |
| EBCVE | 30.38 | 44.55/46.09 | 49.23/42.8 | 46.29/43.64 | 35.19/18.99 | 46.2/43.45 | 34.86/28.07 | 52.44 |
| EBCVD | 44 | 42.93/40.83 | 44.04/37.87 | 44.81/39.64 | 40.38/28.77 | 43.75/39.05 | 30.58/18.55 | 32.43 |
| EBCVC | 30.38 | 44.77/45.33 | 49.01/43.35 | 48.53/42.48 | 36.06/21.13 | 46.66/44.09 | 35.15/26.09 | 49.4 |
| EBCVB | 47.22 | 42.42/39.61 | 45.20/40.08 | 45.40/38.3 | 39.73/35.62 | 46.55/40 | 38.82/23.01 | 39.77 |
| EBCVA | 46.48 | 42.83/39.35 | 45.69/36.75 | 45.40/34.82 | 37.90/36.11 | 46.73/40.19 | 38.20/23.01 | 43.82 |
| BBScV | 40 | 43.10/42.32 | 52.15/48.48 | 49.54/51.38 | 30.81/15.94 | 48.95/49.36 | 25.61/19.61 | 46.15 |
| KLV | 32.89 | 43.80/40.73 | 53.65/51.08 | 48.32/48.62 | 36.67/23.19 | 51.75/49.66 | 31.23/23.28 | 44.87 |
| HeNNV | 37.66 | 43.69/41.72 | 49.44/43.83 | 44.67/40.54 | 39.62/38.03 | 43.08/36.68 | 36.58/21.67 | 41.89 |
| YLV | 30.95 | 44.16/44.01 | 57.86/60.87 | 56.06/47.71 | 34.78/25 | 49.9/48.75 | 36.44/25 | 43.24 |
| LNRSV | 39.19 | 43.73/42.46 | 52.79/51.08 | 51.99/49.54 | 30.95/16.18 | 54.33/52.63 | 27.44/20.53 | 47.3 |
| AcLV | 30 | 44.51/42.1 | 59.45/57.83 | 54.24/52.29 | 34.74/22.86 | 52.65/53.35 | 34.82/25 | 45.12 |
| GalLV | 44.59 | 44.52/44.18 | 54.94/53.02 | 50.72/49.57 | 40.09/37.68 | 45.5/41.43 | 36.84/24.58 | 45.68 |
| HdCMV | 42.11 | 44.91/43.1 | 53.58/49.78 | 46.79/44.55 | 32.00/20.55 | 48.68/45.36 | 33.63/23.73 | 59.49 |
| MjMV | 28.77 | 43.48/41.35 | 54.95/52.38 | 56.57/52.29 |  43.2/34.4 | 56.4/52.1 | 28.72/24.03 | 31.67 |
| NCLV | 36.78 | 44.39/43.08 | 52.53/52.61 | 52.42/49.54 | 33.49/25.71 | 53.17/51.29 | 33.64/24.78 | 41.76 |
| PVS | 42.11 | 44.33/42.28 | 50.40/47.77 | 50.61/49.09 | 35.51/26.03 | 52.7/54.55 | 35.81/26.61 | 42.72 |
| SPCFV | 35.21 | 40.88/35.78 | 45.11/33.2 | 39.22/31.53 | 27.98/26.03 | 40.15/30.06 | 19.29/13.67 | 38.67 |
| PopMV | 42.25 | 43.52/41.6 | 46.19/36.51 | 38.08/42.34 | 37.44/31.08 | 39.47/26.67 | 42.86/40.8 | 47.3 |
| CVB | - | 44.75/41.58 | 53.22/48.92 | 48.80/46.3 | 46.60/30 | 45.83/42.32 | 33.05/26.27 | 30.77 |
| PepVA | 22.08 | 54.04/41.49 | 46.01/37.39 | 38.48/30 | -/- | 52.43/49.83 | 34.96/27.27 | 26.74 |
| HLV | 25 | 44.01/43.88 | 49.21/41.81 | 50.61/43.12 | 32.85/18.57 | 53.74/51.96 | 32.74/27.35 | 37.33 |
| HpMV | 46.05 | 45.58/43.47 | 57.00/56.52 | 55.45/55.05 | 33.04/21.62 | 52.52/49.52 | 35.78/27.43 | 43.96 |
| PRDV | 40.54 | 45.77/42.84 | 51.57/45.69 | 50.15/52.29 | 37.14/21.92 | 50.32/50.65 | 33.03/23.28 | 49.4 |
| PVM | 25.29 | 45.77/42.8 | 59.45/60.43 | 55.45/49.54 | 34.70/24.66 | 54.83/50.16 | 33.91/26.05 | 49.33 |
| HpLV | 28.24 | 45.06/45.13 | 58.48/57.14 | 47.58/43.12 | 32.85/23.53 | 51.77/50.16 | 36.01/22.41 | 48.78 |
| ButMV | 53.52 | 41.81/38.25 | 43.96/36.32 | 39.60/43.48 | 34.82/19.48 | 41.99/34.97 | 50.98/46.53 | 55.81 |
| CPMMV | 26.83 | 47.36/42.12 | 49.65/43.59 | 39.43/30.47 | 26.09/17.57 | 52.43/45.54 | 37.65/31.86 | 18.6 |
| PotLV | 41.46 | 48.14/46.87 | 51.15/43.04 | 53.64/54.63 | 35.55/25.35 | 56.63/58.31 | 36.16/24.77 | 48.1 |
| AHLV | 31.82 | 45.21/46.12 | 49.09/43.64 | 49.24/48.62 | 35.78/22.22 | 42.54/39.2 | 31.97/23.58 | 21.62 |
| PhlVB | 43.24 | 43.82/42.97 | 55.08/51.29 | 48.48/50 | 35.02/34.78 | 49.32/44.48 | 21.46/14.59 | 16.99 |
| PhlVS | 40.54 | 44.32/43.78 | 54.44/52.59 | 53.35/48.15 | 45.83/42.03 | 48.74/43.18 | 34.80/22.88 | 49.4 |
| NSV | 40.54 | 39.32/38.17 | 45.20/32.77 | 38.94/39.17 | 46.51/31.43 | 43.23/36.31 | 21.05/11.76 | 17.57 |
| DVS | 30.12 | 44.08/44.38 | 54.56/55.65 | 46.18/43.12 | 41.12/35.21 | 49.95/47.34 | 38.01/24.58 | 54.67 |
| LSV | 28.57 | 43.33/41.85 | 52.07/45.45 | 50.46/47.71 | 30.33/21.74 | 49.05/50.17 | 25.75/19.31 | 28.77 |
| GLV | 29.87 | 41.06/37.85 | 42.92/33.9 | 41.52/41.96 | 40.58/33.33 | 42.52/33.87 | 44.66/36.89 | 47.42 |
| ALV | 44 | 41.55/39.01 | 38.41/30.2 | 39.40/34.55 | 24.68/37.68 | 47.90/33.22 | -/- | 46.15 |
| GCLV | 29.41 | 41.91/39.74 | 46.05/36.64 | 48.50/44.14 | 50.72/44.12 | 41.47/37.12 | 21.12/11.03 | 21.82 |
| CVNV | 24.71 | 42.36/38.46 | 42.30/33.47 | 41.04/46.85 | 38.57/32.88 | 40.92/31.27 | 20.94/13.67 | 31.68 |
| SPC6V | 43.21 | 42.03/37.46 | 45.15/38.72 | 44.54/40.54 | 31.33/20.93 | 40.51/33.44 | -/- | 6.14 |
| LVA | 43.68 | 45.28/45.14 | 58.15/56.96 | 55.76/51.85 | 30.00/26.09 | 52.07/46.15 | 32.26/32.23 | 39.19 |
| JaVC | 21.43 | 44.79/44.89 | 45.84/42.67 | 46.59/49.07 | 34.30/15.71 | 52.9/50.81 | 33.63/28.21 | 47.25 |
| CapLV | - | -/- | -/- | -/- | -/- | 50.84/48.1 | -/- | - |
| CoLV | - | -/- | -/- | -/- | -/- | 45.16/50.34 | 33.06/28.1 | 31.25 |
| CuVCV | - | -/- | 43.55/39.57 | 41.64/27.27 | 30.00/15.38 | 50.45/46.78 | 34.47/25.83 | 31.31 |
| HeMV | - | -/- | 45.37/36.32 | 47.48/44.14 | 32.55/40 | 44.91/37.06 | 34.10/24.06 | 53.95 |
| MYaV | 38.03 | 39.91/34.87 | 46.24/38.24 | 45.07/31.53 | 26.48/10.96 | 33.82/26.59 | 22.04/19.29 | 36 |
| PhlVM | - | -/- | -/- | -/- | 38.89/27.78 | 53.65/52.24 | 33.04/23.53 | 43.37 |