Supplemental tables summarizing evidence of sidewinding across the snake phylogeny

Table S1

These species use sidewinding as a primary mode of locomotion when undisturbed in nature, and can therefore be considered specialized.

family	species	notes	source
Viperidae (Crotalinae)	*Crotalus cerastes*	This species has long been famous for its specialization for sidewinding, earning its common name as early as 1875.	Klauber 1997, p. 371
		It uses sidewinding on almost any terrestrial surface, except when entering and exiting burrows or in very cluttered area around the base of bushes.	Klauber 1997, p. 376; *pers. obs*.
		The young sidewind at birth.	Klauber 1997, p. 376
		Many detailed kinematics studies have focused on this species.	Jayne 1986; Marvi et al. 2014; Astley et al. 2015
Viperidae (Viperinae)	*Bitis caudalis*	"*Bitis caudalis* tends to move across flat surfaces by utilizing lateral undulations, sometimes combined with rectilinear locomotion. When animals are disturbed, and when the surface area to be crossed has been warmed by the sun, specimens tend to utilize sidewinding with the distance between tracks increasing with body temperature." Some specimens will also jump while sidewinding: "The jumping motion, here described, always occurs as a substitution for one or more sidewinding sequences; most of the time the snake is either excited or unusually warm, and it had often engaged in a relatively rapid, but ineffective, sidewinding sequence."	Gans and Mendelssohn 1971
		Uses sidewinding in soft sand, "but not to the same degree of perfection as in Peringuey's adder (*Bitis peringueyi*)."	Broadley 1983

[continued]	[continued]	"The three specimens collected by the author were found on loose gravel and sandy surfaces. Two specimens behaved as follows: when approached, this adder dispelled its seemingly lethargic characteristics by propelling itself across the surface, away from the author, in a side-winding manner (undulations of its body in lateral curves) at a speed calculated at 1.5m/sec. or approximately 5.5km/hour. On sandy surfaces the frictional marks of these undulatory movements were readily observable."	Hoffmann 1988
Viperidae (Viperinae)	*Bitis peringueyi*	When moving rapidly, it uses only sidewinding locomotion. Its tracks are slightly curly compared to those of the horned viper or the sidewinder rattlesnake.	Mertens 1955
		Favors sidewinding over other types of locomotion regardless of "the hardness of the surface over which it moves."	Brain 1960
		Uses sidewinding on sand. They were also tested on crushed aggregate, but the authors did not report their locomotion.	Gans and Mendelssohn 1971
		Newborn individuals used sidewinding on sand immediately upon breaking free of the membranes surrounding them at birth.	Robinson and Hughes 1978
		It is "essentially a sand-living creature", and has perfected the sidewinding motion, with which it can move startling quickly. It manages to sidewind up dune slopes as steep as 45°.	Broadley 1983
Viperidae (Viperinae)	*Cerastes cerastes*	*Cerastes cornuta* (= *Cerastes cerastes*) shows remarkable convergence to *Crotalus cerastes* in its sidewinding locomotion	Mosauer 1932
		Schnurrenberger described field observations on *Cerastes cerastes* and published photographs of sidewinding tracks. This species often travels long distances in the wild. It seems to prefer areas with fine sand (as opposed to coarse sand), but it sometimes occurs in areas where the ground is hard.	Schnurrenberger 1957
		One individual was followed for over 3 km in the wild. Its route consisted of both fine and coarse sand, and where they met, the snake skirted the edge, apparently avoiding the coarse sand in favor of the fine sand.	Kramer and Schnurrenberger 1958

[continued]	[continued]	This species used sidewinding during locomotion trials on sand. They were also tested on crushed aggregate, but the authors did not report whether they retained sidewinding or switched to other locomotor modes.	Gans and Mendelssohn 1971; Gans and Kim 1992
Viperidae (Viperinae)	*Cerastes gasperettii*	"It is a true sidewinder, never having been seen to employ any other type of locomotion."	Gasperetti 1988
Viperidae (Viperinae)	*Cerastes vipera*	A "flourishing colony" lived at the New York Zoological Park (now the Bronx Zoo) in the early 20th century, distinguishing themselves by their tendency to sidewind rapidly about their cage. Given that the zoo also possessed multiple *Cerastes cerates*, and the curator in charge of reptiles did not mention any observations of sidewinding for the latter species, *Cerastes vipera* may show a stronger tendency to sidewind than does *C. cerastes*.	Ditmars 1910, p. 329
		Early studies to clarify sidewinding kinematics focused on this species.	Mosauer and Wallis 1928; Mosauer 1930
		Tracks for three separate individuals showed that they had each travelled 350-450 m in a single night, using sidewinding.	Mermod 1970
Viperidae (Viperinae)	*Echis carinatus*	"Being an inhabitant of sandy biotopes, *Echis carinata* probably developed sidewinding locomotion as an adaptational mechanism, enabling it to move over sandy terrain, as did other sidewinders." Like *E. colorata*, *E. carinatus* uses sidewinding on sand or smooth surfaces, or when hurrying. However, *E. carinatus* tends to lift its body higher during sidewinding than does *E. coloratus*, "as the typical sidewinders do."	Mendelssohn 1965
		The subspecies *E. carinatus carinatus* "shows almost no sidewinding" while *E. c. leakeyi*, *E. c. sochureki* and *E. c.* sp. from Ethiopia and Northern Kenya do. Additionally, although many *Echis* species use sidewinding on sand, they switch to other modes on crushed aggregate.	Gans and Mendelssohn 1971
Viperidae (Viperinae)	*Eristicophis macmahoni*	It is "well adapted to life on shifting sands," including the evolution of "the very specialized habit of sinking into the sand," a behavior observed in few other sand-dwelling species.	Mendelssohn 1965
		They used sidewinding when tested on sand; although they were also tested on crushed aggregate, the authors did not report the results.	Gans and Mendelssohn 1971; Gans and Kim 1992

Viperidae (Viperinae)	*Pseudocerastes fieldi*	"It is a sidewinder and uses side winding more than *Echis colorata* does, in the typical way, lifting its coils clear off the ground. It uses side winding when moving on a level surface of sand, or, sometimes, on hard, level ground, especially if the surface is smooth, e.g. on a road or on a floor. On such ground the snake sidewinds, especially when frightened, or when ill at ease, for instance, if it is put on such a surface during the day, exposed to the full glare of the sun." "*Pseudocerastes* pays much attention to other sidewinding snakes, whether of its own or of other species. Upon sighting a sidewinding snake it adopts the same type of movement to pursue and overtake the latter, and then uses its tongue to probe and inspect it... Crawling specimens do not arouse the same interest as do sidewinding ones."	Mendelssohn 1965
		Uses sidewinding on sand. They were also tested on crushed aggregate, but the authors did not report their locomotion.	Gans and Mendelssohn 1971; Gans and Kim 1992
Viperidae (Viperinae)	*Pseudocerastes persicus*	"Capable of sidewinding." Note: this source considered *P. persicus* and *P. fieldi* as two subspecies of *P. persicus* - it seems probable that they are similar in their sidewinding behavior.	Spawls and Branch 1995

Table S2

These species don't specialize in sidewinding, but they regularly sidewind in nature.

family	species	notes	source
Boidae	*Candoia aspera*	Regularly uses sidewinding to cross soft, wet mud. Based on a verbal description and a figure drawn from a film of the locomotion, *Candoia* may throw itself forward during this motion, rather than employing a smooth, controlled motion like that of sidewinding vipers like *Crotalus cerastes* or *Bitis peringueyi*.	Bustard 1969
Homalopsidae	*Bitia hydroides*	"Similar to *Cerberus*, we observed *Bitia* using lateral undulatory swimming through water and loose mud and using proficient sidewinding on the surface of harder mud."	Jayne et al. 1995
Homalopsidae	*Cerberus australis*	"When progressing along the ground, a coil of the body is thrown forwards in advance of the head, and then the head is advanced. This action reminds one of the action of the American sidewinder."	Kinghorn 1956
Homalopsidae	*Cerberus rynchops*	A primarily aquatic snake, many individuals were observed on a mud flat exposed after the tide ran out. In this situation, "Its mode of progression is curious. The body is thrown forward in a curve in advance of the head, and the head subsequently advanced, the body being again thrown forward before the snake quite extends itself. It gives the impression of moving sideways."	Wall 1919

[continued]	[continued]	"During field work, I frequently observed sidewinding by undisturbed *Cerberus*on tidal mud flats in Malaysia." This species will readily perform sidewinding as well as lateral undulation on sand, apparently without the need to frighten a snake to elicit sidewinding (unlike for *Nerodia fasciata* in the same study). It may also use sidewinding and lateral undulation when moving on sand: "This snake made a series of parallel tracks (impressions in the sand) grossly resembling the shape and orientation of those produced during sidewinding. During one cycle of activity, the snake displayed R, L, R movement which normally indicates sidewinding. Yet, this snake never established static contact with the substrate and hence was combining aspects of sidewinding with lateral undulation. Rather than the snake stopping as it touched the end, the snake slid within each track (parallel to the length of the track)." "As *Cerberus* increased its speed while moving on sand, pure lateral undulation, lateral undulation combined with sidewinding and then pure sidewinding were used." Kinematics of *Cerberus* sidewinding on sand differ somewhat from kinematics of *Crotalus cerastes*.	Jayne 1986
		In their natural habitat in Malaysia, "snakes usually performed sidewinding locomotion on mud that was firm enough to support their weight. If snakes sank in mud past the first few dorsal scale rows, then lateral undulation was used for surface locomotion as well as swimming through the mud slightly below its surface."	Jayne et al. 1988
		An individual was observed sidewinding on tidal mudflats at a wetland reserve in Singapore.	Chim 2009

Viperidae (Crotalinae)	*Crotalus catalinensis*	“Often sidewinds when moving rapidly across the ground and climbs into vegetation to escape.”	Grismer 2002, p. 326
Viperidae (Viperinae)	*Bitis cornuta*	A captive specimen from the Cape Province, apparently a juvenile only a few weeks old, was observed sidewinding.	Mertens 1955
		"Like *B. xeropaga*, this species is commonly found on rocky mountain sides, but like *Bitis peringueyi and caudali*, it is very fond of burying itself in the sand…" "Together with *caudalis* it displays a sidewinding movement over loose sandy surfaces, but not to the same degree of perfection as Peringuey's or Namid adder (*Bitis peringueyi*).	Broadley 1983
		"It rarely sidewinds or shuffles into loose sand."	Branch 1988
Viperidae (Viperinae)	*Bitis schneideri*	"A specimen collected about 20 km W of Aurus Mountain, Diamond Area 1, was photographed sidewinding up a dune" "It frequently sidewinds and also buries itself in sand."	Haacke 1975
		When moving, "it uses the characteristic rapid sidewinding locomotion that adapts it to its sandy environment."	Hurrell 1981
		"It frequently sidewinds and also buries itself in the sand."	Broadley 1983
		"It sidewinds readily."	Branch 1988
		“South African *schneideri* never showed any signs of sidewinding (over three years of following tracks). However, several of the animals that we found in Namibia did show 'sidewinder' type tracks. This was mostly across largish gaps in the vegetation.”	Bryan Maritz, *pers. comm.*

Viperidae (Viperinae)	*Echis coloratus*	"*Echis colorata* is a sidewinder, like most other desert viperids. Species which show this kind of locomotion are generally inhabitants of more or less sandy areas, *Echis colorata* apparently being the only exception." Mendelssohn hypothesized that the ancestor of *Echis colorata* probably lived on sandy soils and used sidewinding, and that *Echis colorata* retained sidewinding even though it prefers rocky slopes and "is never actually encountered on sandy soils." "Side winding is not an efficient means of locomotion in the typical biotope of *Echis colorata* and is not regularly used by this species. The employment of sidewinding depends to a certain degree on the substrate on which the snake is moving, and on its state of stimulation." "On hard, level ground, e.g., on a smooth road or on a floor, pure side winding is used when the snake is hurrying, otherwise serpentine and rectilinear movements are combined with side winding. On level, rough ground, *Echis colorata* progresses by serpentine and rectilinear movement, side-winding only being resorted to if the snake is extremely frightened." "*Echis colorata* tends less to lift its coils, but rather to push them ahead on the ground."	Mendelssohn 1965
		They used sidewinding when tested on sand, lateral undulation on crushed aggregate.	Gans and Mendelssohn 1971

Table S3

These species have not been documented sidewinding when undisturbed in nature, but they readily sidewind under specific conditions.

family	species	notes	source
Colubridae (Natricinae)	*Natrix maura*	When it performed sidewinding on a smooth surface in the lab, it maintained three regions of static contact with the ground at any given time. It differed from sidewinding vipers like *Cerastes cerastes* in that it moved more quickly, and it maintained shorter segments of the body in static contact with the ground, while the raised segments of the body were relatively long. It appeared to waste considerable energy due to slippage. Sidewinding appears to have been induced as an escape behavior.	Gasc 1974, pp. 129-132
Colubridae (Natricinae)	*Natrix natrix*	"When a grass snake moves over a relatively smooth and uniform surface its mode of progression tends to be irregular, and serpentine movement is replaced either by side-winding, or by concertina movement, or a combination of the two. The precise mechanical conditions of the substratum necessary for the elicitation of sidewinding in its most characteristic form cannot be defined at present, but an instance is shown in PI. 6(C), in which the animal is moving over a painted metal plate." This species would not or could not sidewind on sandpaper.	Gray 1946
		Performed sidewinding on a smooth surface in the lab (fig. 106 shows *Natrix natrix*; most of the rest of the discussion in this paper seems to focus on *Natrix maura*).	Gasc 1974, pp. 129-132

Colubridae (Natricinae)	*Nerodia fasciata*	Small individuals readily performed a combination of lateral undulation and sidewinding when placed on sand, but they normally had to be frightened to perform pure sidewinding. Velocity profiles showed that when sidewinding, it was more variable than either *Crotalus cerastes* or *Cerburus rynchops* in terms of when, during a cycle, it reached its maximum speed. It remained in static contact with the ground for less time than did *Crotalus cerastes*.	Jayne 1986
		Jayne used electromyography to characterize the muscular activity of *N. fasciata* sidewinding on a linoleum floor.	Jayne 1988
		Some neonates sidewind when placed on sand, with varying proficiency.	*pers. obs.*
Colubridae (Natricinae)	*Nerodia rhombifer*	Some large *Nerodia rhombifer* (~450 g) used sidewinding "on an unpaved road that consisted of compacted clay and rounded gravel. Although most of the sidewinding was high-speed and nearly jumping, at one point they slowed down and had a beautifully coordinated pattern of sidewinding."	Bruce Jayne, *pers. comm.*
		Some neonates sidewind when placed on sand, with varying proficiency. Some larger individuals also sidewind on sand.	*pers. obs.*
Colubridae (Natricinae)	*Nerodia sipedon*	Some neonates sidewind when placed on sand, with varying proficiency.	*pers. obs.*
Colubridae (Natricinae)	*Nerodia taxispilota*	Some neonates sidewind when placed on sand, with varying proficiency.	*pers. obs.*
		Several have been observed sidewinding quickly and proficiently across a paved road as an escape behavior.	Noah Carl, *pers. comm.*

Colubridae (Natricinae)	*Opisthotropis typica*	An adult performed proficient sidewinding when placed on a flat cement floor in captivity. Two sections of the body were in contact with the floor at a given time, and the front of the body was lifted well above the floor while moving. Was "easily induced to perform this sidewinding motion continuously" except when exhausted.	Mori 1993
Colubridae (Natricinae)	*Regina septemvittata*	Some neonates sidewind when placed on sand.	Bruce Jayne, *pers. comm.*
Colubridae (Natricinae)	*Storeria dekayi*	"Capable of adopting a movement essentially like the sidewinding of *Cerastes vipera* when they are obliged to move on a smooth floor."	Mosauer 1930
Colubridae (Natricinae)	*Thamnophis* sp.	Ditmars reported sidewinding in "*Eutaenia elegan*s variety *infernalis*," which may refer to either *Thamnophis elegans* or *Thamnophis sirtalis infernalis*." "It progresses in a rapid series of close, S-shaped movements and generally in an oblique direction to that in which the head is pointing-an evolution performed, though at greatly reduced speed, by the 'side-winder' rattlesnake. While making off in this fashion, if the snake is closely pursued, it will actually leap forward, for a distance of nearly a foot, by suddenly straightening the body." "Of a large number of specimens, comprising three separate shipments, all displayed the same agile movements."	Ditmars 1908, p. 227
		They "sidewind with considerable success" when placed on a smooth surface.	Klauber 1997, p. 375
Colubridae (Natricinae)	*Thamnophis ordinoides*	Higham captured video for several (~10) adult individuals from a population on Vancouver Island, which sidewind readily and very proficiently when placed on soft beach sand.	Tim Higham, *pers. comm.*

Colubridae (Natricinae)	*Thamnophis sirtalis*	"Capable of adopting a movement essentially like the sidewinding of *Cerastes vipera* when they are obliged to move on a smooth floor."	Mosauer 1930
		They occasionally use sidewinding when attempting to escape rapidly while on a linoleum floor.	Bruce Jayne, *pers. comm.*
		Performs incipient sidewinding. If the snake is rushed, this movement turns into jumping with a stretched body.	Helmcke et al. 1962
Colubridae (Pseudoxenodontinae)	*Pseudoxenedon macrops*	A young individual performed proficient sidewinding when placed on a flat cement floor in captivity. Two sections of the body were in contact with the floor at a given time, and the moving portions of the body were lifted only slightly, such that they slid along the ground. Was "easily induced to perform this sidewinding motion continuously" except when exhausted.	Mori 1993
Elapidae	*Cryptophis nigrostriatus*	Sidewinds in a manner similar to *Parasuta dwyeri* and *Suta punctata* except that “the anterior part of the more elongate body forms more regular waves”	Scanlon 2001
Elapidae	*Denisonia devisi*	When tested on a smooth wooden table, it “has a relatively slow and ‘deliberate’ sidewinding pace, at least as an adult. This was observed within hours after obtaining a specimen… so it is surprising that it has not been recorded previously.”	Scanlon 2001
Elapidae	*Ephalophis greyae*	A video recording shows one individual sidewinding slowly and deliberately across sand, with well-coordinated movements.	Brendan Schembri, *pers. comm.*
Elapidae	*Parasuta dwyeri*	When tested on a smooth wooden table, they “have a rapid style of sidewinding in which the posterior body and tail appear to ‘flick’ against the substrate, reminiscent of the saltational escape locomotion of [the pygopodid lizard] *Delma* spp.”	Scanlon 2001

Elapidae	*Suta punctata*	When tested on a smooth wooden table, they “have a rapid style of sidewinding in which the posterior body and tail appear to ‘flick’ against the substrate, reminiscent of the saltational escape locomotion of [the pygopodid lizard] *Delma* spp.”	Scanlon 2001
Homalopsidae	*Homalopsis buccata*	The following description applies to an unspecified number of individuals, apparently observed on a tiled laboratory floor: "On dry land, the animal rises the first third of the body, takes the head a little backwards and projects it then forward with some strength so that the body seems to be dragged after it. This is repeated and the animal proceeds thus more or less litterally [sic] with leaps and bounds. However the movement can be swift and makes then at first the impression of gliding with waves in a vertical plane, more than that of jumping."	Bergman 1951
Lamprophiidae	*Boaedon fuliginosus*	Normally uses lateral undulation, but "when released on a smooth surface, devoid of adequate superficial projections, resorts to sidewinding which allows fairly rapid locomotion. The movement is, however, seldom regular and is punctuated by frequent stops. This fact makes it difficult to obtain a satisfactory track on sooted cardboard since after producing two or three parallel lines, the snake is inclined to rest and then on starting again, to erase the existing tracks with its tail. Fortunately, some undamaged records have been obtained and these do not differ substantially from the ones made by Peringuey's adder."	Brain 1960
Pythonidae	*Aspidites ramsayi*	A video shows one individual sidewinding very slowly on apparently firm, open ground, keeping its body behind its head relative to the person recording the video.	Brendan Schembri, *pers. comm.*

Tropidophiidae	*Tropidophis haetianus*	Two juveniles and one adult male, all captured in the wild, used sidewinding as an escape behavior. "All three animals used the same pattern of locomotion on a variety of substrates, including a tile floor, carpet, a tightly stretched sheet, poured concrete, grass, and sand. The adult female was gravid and resisted all attempts to induce movement by refusing to uncoil from a defensive ball. The sidewinding pattern (Fig. 1) resembled that of *Crotalus cerastes* and left a similar track in sand. It differed, however, in that the direction of movement was more parallel to the long body axis than in sidewinding rattlesnakes. Individuals 'looped' their bodies to either the left or right as they moved in a forward direction."	Smith et al. 1991
Tropidophiidae	*Tropidophis melanurus*	It "is a far more capable sidewinder than any colubrid that I have seen."	Bogert 1947
Viperidae (Crotalinae)	*Agkistrodon piscivorus*	When placed on a linoleum floor, a juvenile performed well-coordinated sidewinding with several successive cycles of movement, allowing Jayne to collect EMGs (unpublished data). On another occasion, he observed similarly nice sidewinding of sub-adults on an old asphalt road in southern Florida.	Bruce Jayne, *pers. comm.*
Viperidae (Crotalinae)	*Bothrops ammodytoides*	They sidewind across both sand and gravel as an escape behavior.	Robert Espinoza, *pers. comm.*; YouTube: gavensmar
Viperidae (Crotalinae)	*Bothrops jararaca*	Small individuals have been observed using "a locomotor mode similar to sidewinding (apparently combined with lateral undulation)" when "found away from cover and fleeing over open areas with smooth surfaces, such as sandy trails."	Sazima 1992
Viperidae (Crotalinae)	*Echis pyramidum*	"When agitated may also sidewind, moving at astonishing speed!"	Spawls and Branch 1995

Table S4

This table includes isolated or uncertain observations of sidewinding or locomotion resembling sidewinding.

family	species	notes	source
Boidae	*Boa constrictor*	Gans and Mendelssohn claimed to have footage of a medium-sized "*Constrictor*" (presumably *Boa constrictor*) performing "a primitive form of sidewinding."	Gans and Mendelssohn 1971
Boidae	*Eunectes murinus*	One individual resorted to sidewinding in an attempt to escape humans on firm, grassy ground (captured on video).	Ryerson and Horwitz 2014; YouTube
Colubridae: Colubrinae	*Phllorhynchus decurtatus*	When placed on very hot sand (60°C), they "were stimulated to their utmost speed" and approximated sidewinding, but based on a photograph of their tracks, they performed only a limited number of cycles in between bouts of lateral undulation, and they did not lift their bodies completely off the ground as a proficient sidewinder would.	Cowles 1941
Colubridae: Colubrinae	*Sonora occipitalis*	When placed on very hot sand (60°C), they "were stimulated to their utmost speed" and approximated sidewinding, but based on a photograph of their tracks, they performed only a limited number of cycles in between bouts of lateral undulation, and they did not lift their bodies completely off the ground as a proficient sidewinder would.	Cowles 1941
Colubridae: Dipsadinae	*Hypsiglena ochrorhynchus*	When placed on very hot sand (60°C), they "were stimulated to their utmost speed" and approximated sidewinding, but based on a photograph of their tracks, they performed only a limited number of cycles in between bouts of lateral undulation, and they did not lift their bodies completely off the ground as a proficient sidewinder would.	Cowles 1941
Colubridae: Natricinae	*Thamnophis hammondii*	Secondhand report of sidewinding over hard, open ground.	Cowles 1956

Elapidae	*Acanthophis antarticus*	"H. Ehmann (pers. comm., 1999) records sidewinding in two additional species not covered by my own observations. In about 1970 he observed (and filmed) sidewinding by a hot and agitated adult *Acanthophis antarcticus* (Southern Death Adder): 'It was a recently captured SA coastal adult released to "perform" on a bare and rather warm dense, fine red sand dune about 400 km inland.'"	Scanlon 2001
Elapidae	*Laticauda colubrina*	Twenty-four Banded Sea Kraits were found together in a sandy area, in close association with tracks resembling sidewinder tracks. The tracks appeared to have been made by at least eight different individuals.	Heatwole and Abbott 1998
Elapidae	*Naja tripudians*	Wall reported a secondhand observation of “peculiar progression” that "moved along like a huge caterpillar, hunching his back, and then using his head as a fulcrum to draw himself along" - it is unclear whether this locomotion represents sidewinding, and it is also unclear whether the snake moved strangely in a desperate escape attempt, or whether it may have been injured.	Wall 1907
Elapidae	*Suta suta*	"Ehmann (pers. comm.) also states that *Suta suta* (Curl Snake) sidewinds, 'at least big/fat/gravid ones'."	Scanlon 2001
Homalopsidae	*Fordonia leucobalia*	“Two specimens were found under a pile of timber at an aboriginal camp site on a sandbank in a mangrove swamp at Cape Don. Their presence was indicated by tracks made in the sand early in the morning; the tracks indicate that this species progresses by a distinctive ‘sidewinding’ locomotion.”	Cogger and Lindner 1974
Pythonidae	*Python bivittatus*	A python (presumably a Burmese Python) was captured on video using a sidewinding-like motion to cross a smooth floor after it fell through the ceiling of a Chinese bank. The snake does not perform many cycles of the motion. This video was shared on YouTube, and many news outlets reported the story.	e.g. BBC, Global News, The Independent, NDTV, Science Alert, YouTube: CCTV

Pythonidae	*Python curtus*	In tests of crawling endurance involving nine wild-caught individuals, they soon switched from lateral undulation to sidewinding.	Rozar 2010
Viperidae: Crotalinae	*Crotalus* spp. *(atrox, helleri, pyrrhus, ruber, scutulatus, viridis)*	Klauber placed several rattlesnake species on "polished wood or linoleum floors to determine the degree to which they would adopt sidewinding on surfaces unsatisfactory for ordinary snake locomotion. In general, although it was noted that all of these rattlers could and did sidewind, the motion was far from being a facsimile of the practiced grace of the sidewinder. First, the coils were not as widely thrown, and they were more nearly perpendicular to the axis of the body rather than at a sharp angle, as with the sidewinder. The several elements of motion were not even and continuously flowing; rather, they tended to be spasmodic and separate. The result was a much reduced efficiency, as measured by speed and expended effort. Some of the rattlers were virtually reduced to purposeless thrashing, or at least to a continuous effort to find irregularities in the floor surface that might serve as pegs against which to push the body." "In my experiments, I found that much depended on the snake's objective and the degree of its alarm. Those that were not unduly frightened tried all forms of locomotion, at times simultaneously with different elements of the body; they mixed all combinations-undulatory, sidewinding, rectilinear, and concertina-in their endeavors to get a purchase on the smooth floor."	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus atrox*	One individual gave “a seemingly perfect duplication of sidewinding,” apparently on a hot surface.	Cowles 1956

[continued]	[continued]	See Klauber's description under *Crotalus* spp. "Dr. R.B. Cowles has advised me by letter that one western diamond back (*C. atrox*), a snake that lives in sidewinder territory, but does not ordinarily sidewind, when placed on linoleum went into perfect sidewinding and flowed across the floor without the slightest effort or confusion." (this account may correspond to the same individual mentioned in Cowles 1956)	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus helleri*	See Klauber's description under *Crotalus* spp. "One southern Pacific rattler (*C. v. helleri*) was fairly successful" at sidewinding when placed on a smooth floor.	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus pyrrhus*	Young of this species have been observed to resort to sidewinding (or something resembling it) in situations of extreme fear or discomfort.	Cowles 1941
		See Klauber's description under *Crotalus* spp.	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus ruber*	See Klauber's description under *Crotalus* spp.	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus scutulatus*	See Klauber's description under *Crotalus* spp.	Klauber 1997, p. 375
Viperidae: Crotalinae	*Crotalus viridis*	See Klauber's description under *Crotalus* spp.	Klauber 1997, p. 375
Viperidae: Viperinae	*Bitis arietans*	"When forced to move rapidly on a flat surface even *Bitis arietans* resorts to sidewinding, but it is a crude performance compared to that of *Crotalus cerastes*."	Bogert 1947
		"When attempting to escape it can move quickly, in a rather stiff-bodied lateral undulation that is reminiscent of sidewinding."	Spawls and Branch 1995

Viperidae: Viperinae	*Bitis gabonica*	Ditmars described it as a “looper” or “sidewinder” without stating the source of his information. He also called it a creature of "sterile, sandy places" when they are now known to primarily inhabit rainforests, leading one to question the veracity of his account.	Ditmars 1910, p. 325
Viperidae: Viperinae	*Trimeresurus gramineus*	“One brought to me alive moved in a remarkable manner. It threw forward its body, and then advanced the head and forebody till straight, and repeated the action. It thus appeared to progress sideways, and did so in a laboured fashion.”	Wall 1926
Viperidae (Viperinae)	*Vipera latastei*	A book on the wildlife of Andalusia shows a photograph of *V. latastei* tracks in the sand at Coto Doñana. These tracks clearly do not correspond to sidewinding locomotion.	Vaucher 1967
		“The southern subspecies, *V. l. gaditana* is a good sidewinder in the sand dunes of Coto Donana in southern Spain.”	Mallow et al. 2003
		The information in Mallow et al. (2003) comes from the observations of one of the book's authors, who has seen tracks associated with *V. l. gaditana* in sand dunes on several occasions.	Göran Nilson, *pers. comm.*

References

Astley HC, Gong C, Dai J, Travers M, Serrano MM, Vela PA, Choset H, Mendelson JR, Hu DL, Goldman DI. 2015. Modulation of orthogonal body waves enables high maneuverability in sidewinding locomotion. Proc Natl Acad Sci 112:6200–6205.

Bergman RAM. 1951. The anatomy of *Homalopsis buccata*. Proceedings 54:511–24.

Bogert CM. 1947. Rectilinear locomotion in snakes. Copeia 1947:253.

Brain CK. 1960. Observations on the locomotion of the south west African adder, *Bitis peringueyi* (Boulenger), with speculations on the origin of sidewinding. Ann Transvaal Mus 24:19–24.

Branch WR. 1988. Field Guide to the Snakes and Other Reptiles of Southern Africa Sanibel Island, Florida: Ralph Curtis Books.

Broadley DG. 1983. Fitzsimmons' Snakes of Southern Africa Johannesburg: Delta Books.

Bustard HR. 1969. Defensive behavior and locomotion of the Pacific boa, *Candoia aspera*, with a brief review of head concealment in snakes. Herpetologica 164–170.

Chim CK. 2009. Population ecology of the dog-faced water snake *Cerberus rynchops* at Sungei Buloh Wetland Reserve, Singapore (Master's).

Cogger HG, Lindner DA. 1974. Frogs and reptiles. In: Frith HJ, Calaby JH, editors. Fauna Survey of the Port Essington District, Cobourg Peninsula, Northern Territory of Australia Melbourne: Commonwealth Scientific and Industrial Research Organization.

Cowles RB. 1941. Observations on the Winter Activities of Desert Reptiles. Ecology 22:125.

Cowles RB. 1956. Sidewinding locomotion in snakes. Copeia 1956:211.

Ditmars RL. 1908. The Reptile Book New York: Doubleday, Page & Company.

Ditmars RL. 1910. Reptiles of the World: Tortoises and Turtles, Crocodilians, Lizards and Snakes of the Eastern and Western Hemispheres New York: The Macmillan Company.

Gans C, Kim HL. 1992. Kinematic description of the sidewinding locomotion of four vipers. Isr J Zool 38:9–23.

Gans C, Mendelssohn H. 1971. Sidewinding and jumping progression of vipers. In: De Vries A, Kochva E, editors. Toxins of animal and plant origin New York: Gordan and Breach, Science Publishers, Inc. p. 17–38.

Gasc J-P. 1974. L'interprétation fonctionnelle de l'appareil musculo-squelettique de l'axe vertébral chez les serpents (Reptilia). Mém Muséum Natl Hist Nat Sér Zool 83:1–182.

Gasperetti J. 1988. Snakes of Saudi Arabia. In: Büttiker W, Krupp F, editors. Fauna of Saudi Arabia Basel: Pro Entomologia. p. 169–450.

Gray J. 1946. The mechanism of locomotion in snakes. J Exp Biol 23:101–120.

Grismer LL. 2002. Amphibians and Reptiles of Baja California Including its Pacific Islands and the Islands in the Sea of Cortés Berkeley and Los Angeles: University of California Press.

Haacke WD. 1975. Description of a new adder (Viperidae, Reptilia) from Southern Africa, with a discussion of related forms. Cimbebasia 4:115–28.

Heatwole H, Abbott P. 1998. Evidence for sidewinding in the banded sea-krait. Herpetofauna 28:14–15.

Helmcke JG, Lengerken JV, Starck D. 1962. Ordnung der Klasse Reptilia, Serpentes, Handbuch der Zoologie Berlin: Walter de Gruyter & Co.

Hoffmann LAC. 1988. Note on the ecology of the horned adder *Bitis caudalis* (A. Smith) from Gobabeb, Namib-Naukluft Park. J Herpetol Assoc Afr 35:33–34.

Hurrell DP. 1981. Namaqua dwarf adder bite. S Afr Med J 59:491–492.

Jayne BC. 1986. Kinematics of terrestrial snake locomotion. Copeia 1986:915.

Jayne BC. 1988. Muscular mechanisms of snake locomotion: An electromyographic study of the sidewinding and concertina modes of *Crotalus cerastes*, *Nerodia fasciata* and *Elaphe obsoleta*. J Exp Biol 140:1–33.

Jayne BC, Voris HK, Heang KB. 1988. Diet, feeding behavior, growth and numbers of a population of *Cerberus rynchops* (Serpentes: Homalopsinae) in Malaysia. Fieldiana Zool 50:1015.

Jayne BC, Ward TJ, Voris HK. 1995. Morphology, reproduction, and diet of the marine Homalopsine snake *Bitia hydroides* in peninsular Malaysia. Copeia 1995:800.

Kinghorn JR. 1956. The Snakes of Australia. 2nd ed Sydney: Angus & Robertson.

Klauber LM. 1997. Rattlesnakes: Their Habits, Life Histories, and Influence on Mankind. Second Edition. ed Berkeley, Los Angeles, London: University of California Press.

Kramer VE, Schnurrenberger H. 1958. Zur schlangenfauna von Libyen. Aquar- Terr Z 11:56–59.

Mallow D, Ludwig D, Nilson G. 2003. True Vipers: Natural History and Toxinology of Old World Vipers Malabar, Florida: Krieger Publishing Company.

Marvi H, Gong C, Gravish N, Astley H, Travers M, Hatton RL, Mendelson JR, Choset H, Hu DL, Goldman DI. 2014. Sidewinding with minimal slip: Snake and robot ascent of sandy slopes. Science 346:224–29.

Mendelssohn H. 1965. On the biology of the venomous snakes of Israel II. Isr J Zool 14:185–212.

Mermod C. 1970. Domain vital et déplacements chez *Cerastes vipera* et *Cerastes cerastes* (Reptilia, Viperidae). Rev Suisse Zool 77:555–61.

Mertens R. 1955. Die amphibien und reptilien Südwestafrikas: Aus den ergebnissen einer im Jahre 1952 ausgeführten Reise. Abh Senckenberg Naturforschenden Ges 490:1–172.

Mori A. 1993. A note on the sidewinding locomotion in two colubrid snakes Opisthotropis typica and Pseudoxenodon macrops. The Snake 25:67–70.

Mosauer W. 1930. A note on the sidewinding locomotion of snakes. Am Nat 64:179–183.

Mosauer W. 1932. Adaptive convergence in the sand reptiles of the Sahara and of California: A study in structure and behavior. Copeia 1932:72.

Mosauer W, Wallis K. 1928. Beitrage zur kenntnis der reptilienfauana von Tunisien. Zool Anz 79:195–207.

Robinson MD, Hughes DA. 1978. Observations on the natural history of Peringuey's Adder, *Bitis peringueyi* (Boulenger)(Reptilia: Viperidae). Ann Transvaal Mus 31:189–193.

Rozar RC. 2010. The role of morphology in the locomotor performance of arboreal snakes (Doctoral).

Ryerson WG, Horwitz S. 2014. *Eunectes murinus* (Green Anaconda): Behavior/sidewinding. Herpetol Rev 45:337–38.

Sazima I. 1992. Natural history of the Jararaca pitviper, *Bothrops jararaca*, in Southeastern Brazil. In: Campbell JA, Brodie ED, editors. Biology of the Pitvipers Tyler, Texas: Selva. p. 199–216.

Scanlon JD. 2001. Sidewinding in terrestrial Australian elapid snakes. Herpetofauna 31:11–18.

Schnurrenberger H. 1957. Het leven van *Aspis cerastes* (Linné) in de vrije natuur. Lacerta 16:58–60.

Smith DD, Parmerlee JS, Powell R, White LR, Lathrop A. 1991. Natural history notes (locomotion): *Tropidophis haetianus*. Herpetol Rev 22:132–33.

Spawls S, Branch B. 1995. The Dangerous Snakes of Africa Sanibel Island, Florida: Ralph Curtis Books.

Vaucher C-A. 1967. Wild Andalusia: Coto Doñana Lausanne, Switzerland: Editions Marguerat.

Wall F. 1907. Peculiar progression of a cobra. J Bombay Nat Hist Soc 18:209–10.

Wall F. 1919. A popular treatise on the common Indian snakes. J Bombay Nat Hist Soc 26:88–93.

Wall F. 1926. Snakes collected in Burma in 1925. J Bombay Nat Hist Soc 31:558–66.