Chinese is typically characterized by the co-existence of visuospatial and phonological disorders in a dyslexic child. This pattern of behavioral and pathophysiological profiles is different from that in English dyslexia, which is generally associated with a core phonological deficit in the absence of abnormal visual processing [7].

Supplemental Data
Supplemental data are available at http://www.cell.com/current-biology/supplemental/S0960-9822(09)01549-8

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Herbivory in a spider through exploitation of an ant–plant mutualism
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Spiders are thought to be strict predators [1]. We describe a novel exception: Bagheera kiplingi, a Neotropical jumping spider (Salticidae) that exploits a well-studied ant–plant mutualism, is predominantly herbivorous. From behavioral field observations and stable-isotope analyses, we show that the main diet of this host-specific spider comprises specialized leaf tips (Beltian food bodies; Figure 1A) from Vachellia spp. ant-acacias (formerly Acacia spp.), structures traded for protection in the plant’s coevolved mutualism with Pseudomyrmex spp. ants that inhabit its hollow thorns [2]. This is the first report of a spider that feeds primarily and deliberately on plants.

Jumping spiders use advanced color-vision, agility, and cognitive skills to prey upon invertebrates [3]. The Salticidae is the largest family of spiders (>5,000 species), and members of this diverse group employ a broad range of foraging strategies. However, departures from carnivory in salticids — or in any of the 40,000 described spiders — are rare [1]: several cursorial spiders imbibe nectar as an occasional food source [4], and some juvenile orb-weavers incidentally ingest pollen when recycling their webs [5].

We discovered herbivory in B. kiplingi during field studies in southeastern Mexico (Quintana Roo, involving V. collinsii acacias inhabited by P. peperi ants) and northwestern Costa Rica (Guanacaste Province, involving V. collinsii and V. cornigera inhabited by P. spinicola, P. flavicornis, or P. nigrocincta). Between 2001 and 2008, we systematically observed individual B. kiplingi in these two regions to study foraging behavior. We supported direct observations of spiders in Mexico with high-definition videography.

Individuals at both sites fed predominantly on Beltian bodies, which represented nearly the full diet of spiders in Mexico (91% of items consumed) but relatively less in Costa Rica (60%; $\chi^2 = 14.2$, df = 3, $P < 0.05$; Figure 1B). Spiders occasionally supplemented Beltian bodies with extraloral nectar, another resource central to the ant–acacia mutualism [2]. They also preyed on acacia-ant larvae, small nectar-feeding flies, and (rarely) smaller conspecifics.

We observed focal B. kiplingi circumventing the well-known defenses of the acacia’s Pseudomyrmex ant-inhabitants, which keep the plant free of most herbivores and encroaching vegetation [2]. These spiders occur almost exclusively on ant-occupied acacias, where they breed year-round and generally build their nests at the distal tips of older leaves (86%; N = 110) that have low rates of ant patrol (see Supplemental Data available on-line). Foraging B. kiplingi actively avoid ant-guards and exhibit situation-specific strategies (for example, changing targets if approached by ants) when harvesting Beltian bodies and when taking nectar or ant larvae (Supplemental Movies S1–S5).

Stable-isotope analyses confirmed B. kiplingi herbivory (Figure 1C; see also Supplemental Data). Our results are consistent with other food-web studies: the tissues of herbivores tend to have lower $^{15}$N:$^{14}$N ratios (expressed as $\delta^{15}$N) relative to carnivores, whereas consumers tend to match $^{15}$C:$^{12}$C ratios ($\delta^{15}$C) of their food [6]. Mexican B. kiplingi specimens had $\delta^{15}$N profiles averaging 4.8% lower than those of other jumping spiders from surrounding vegetation, but only 2.1% and 2.9% higher than ant workers and Beltian bodies, respectively. B. kiplingi spiders and ant workers at this site had $\delta^{13}$C signatures virtually identical to those of Beltian bodies, whereas other spiders exhibited $\delta^{13}$C values that did not match those of Beltian bodies.

Using dietary mixing models (see Supplemental Data), we estimate that B. kiplingi in Mexico (N = 50) derive >95% of assimilated C and N from ant-acacias, including 89 ± 13.2% (mean ± SE) directly from plant tissue and 8 ± 7.9% indirectly from acacia-ant larvae. Individuals of all age-sex classes had similar diets, suggesting that spiders in this population are
near-total vegetarians throughout their lives. Analyses of Costa Rican specimens (N = 11) indicated a larger contribution of other animal prey to the diet of spiders there (Supplemental Figure S1), consistent with feeding patterns observed in the field (Figure 1B).

A widespread and intimate distributional association exists between B. kiplingi and myrmecophytic Vachellia spp. The spider’s known geographic range coincides with that of ant–acacia systems throughout Mesoamerica (Figure S2). Hundreds of individual B. kiplingi may inhabit a single ant-acacia, yet during a seven-year inventory of all salticids at our Costa Rican site (N = 1174 individuals from 48 species), we observed only two B. kiplingi individuals on plants other than Vachellia spp. In both Mexico and Costa Rica, we also found nests of B. kiplingi (N > 200) only on ant-acacias or adjacent foliage. Reports of host-plant specificity in a spider are rare [7], and no spider has been shown previously to exploit the specific resources exchanged in any mutualism.

Consumption of Beltian bodies by B. kiplingi may derive from foraging on other static food sources, such as acacia-ant larvae or eggs of other insects. However, while enriched in sugar and protein, these low-fat food bodies are 80% structural fiber [8] and are thus poor surrogates for animal prey. Given that no other spider is known to feed on vegetation, the digestive physiology of B. kiplingi may be specialized to process such a fibrous, nitrogen-poor material [9]. Year-round availability of ant-plant food [2], combined with indirect defensive benefits possibly conferred by the acacia-ants [10], may also help explain how the spider’s carnivorous ancestor transitioned to herbivory.

The host-specific natural history of B. kiplingi demonstrates that commodities modified for trade in a pairwise mutualism can, in turn, shape the ecology and evolutionary trajectory of other organisms that intercept these resources. Here, one species within an ancient lineage of carnivorous arthropods — the spiders — has achieved herbivory by exploiting plant goods exchanged for animal services. While the advanced sensory-cognitive functions of salticids [3] may have pre-adapted B. kiplingi for harvesting Beltian bodies, this spider’s unprecedented trophic shift was contingent upon the seemingly unrelated coevolution between an ant and a plant.

Supplemental Data
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